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ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 9/2
CORPS-WIDE CONFERENCE ON COMPUTER-AIDED DESIGN IN STRUCTURAL EN--ETC(U)
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CORPS-WIDE CONFERENCE ON

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VOLUME X STIFFNESS METHODS, FRAMES, and MILITARY ENGINEERING

22-26 September 1975

Edited by N. RADHAKRISHNAN

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August 1976

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

by Automatic Data Processing Center
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Mississippi 39180

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Unnumbered	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CORPS-WIDE CONFERENCE ON COMPUTER-AIDED DESIGN IN STRUCTURAL ENGINEERING. VOLUME X. STIFFNESS METHODS, FRAMES, AND MILITARY CONSTRUCTION		5. TYPE OF REPORT & PERIOD COVERED Volume 10 of 12 volumes
7. AUTHOR(s) William D. Ashton, Daniel Reynolds Donald B. Baldwin, edited by N. Radhakrishnan		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Automatic Data Processing Center P. O. Box 631, Vicksburg, MS 39180		8. CONTRACT OR GRANT NUMBER(s) 12 194p.
11. CONTROLLING OFFICE NAME AND ADDRESS Office, Chief of Engineers, U. S. Army Washington, DC 20314		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE Aug 76
		13. NUMBER OF PAGES 191
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) Presented at Corps-wide Conference on Computer-Aided Design in Structural Engineering, 22-26 September 1975, New Orleans, LA.		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Computer-aided design--Congresses Computer programs Design--Congresses Military construction Structural engineering--Congresses Stiffness methods Building frames		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) ASHTON - Matrix analysis, which employs the finite element method, is the accepted Corps technique for analyzing structures. It is a powerful tool for the analysis of two-dimensional continuums, as well as for the design of beams, trusses, and frames. Recent advances in interactive graphics will make these analyses even more useful to the designer. This paper briefly summarizes the basic concepts and coding procedures common to all program packages. The di- rect stiffness method of structural analysis, involving simultaneous equations (Continued)		

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20. ABSTRACT (Continued).

in matrix form, is surveyed. The input data required for all direct stiffness programs (identification data, control data, material properties, nodal point description, and element definition) are discussed.

REYNOLDS - This report deals with computer-aided design for building frames, specifically in the area of analysis programs. Three examples of the work done in the Sacramento District are provided. The first, the Post Chapel at the Presidio in San Francisco, California, required repairs to a deflected building frame. A computer model was used to match the shape of the deflected frame and then to determine the forces necessary to correct the problem. The second example is the Weapons Evaluation Facility at Yuma, Arizona. The facility was designed with the help of computer analysis. One particular problem was to construct a door between two bays of the facility that could support a building frame at its center as well as unsymmetrical crane loads perpendicular to the plane of the truss on its sides. Computer three-dimensional analysis aided in solving this problem. The third problem dealt with the adaptation of a roof frame plan for the dental clinic at Fort Ord, California, so that adequate space was provided for mechanical ducts. The computer model not only provided adequate space but also represented an \$18,800 savings from the original roof frame plan. This report also lists problems encountered by engineers in computer analysis, suggests ways to improve computer usage, and recommends the development of programs on a common data basis with subprograms that can be linked together and tailored to a systems approach. Also included is a two-dimensional steel-frame problem sent to various Districts and the computer programs used to solve it.

BALDWIN - In recent years, architectural and engineering design for military construction has been complicated by new regulations and technical factors. Environmental and energy conservation considerations, the effects of rapid inflation on material and construction costs, and the effect of energy shortages have all added to the problem. With all the complex factors facing Corps designers, more effective use of the computer is required. The Military Construction Directorate is developing a computer system for the coordinated integration of engineering and architectural components of the MCA design process. This is the Automated Engineering and Architectural Design System, AEADS, an optimum mix of software and hardware to aid the professional in making design decisions. This paper discusses objectives and development strategy for AEADS and evaluates SEARCH and the DD 1391 Checker.

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PREFACE

In December 1974, the Automatic Data Processing (ADP) Center, U. S. Army Engineer Waterways Experiment Station (WES), submitted a proposal to conduct a Corps-wide Conference on Computer-Aided Design in Structural Engineering (CADSE) to the Office, Chief of Engineers (OCE). OCE approved the proposal and efforts were started in February 1975 to conduct this Conference. The Conference was conducted in New Orleans, Louisiana, 22-26 September 1975 and was attended by 175 engineers from 48 Corps field offices, OCE, Construction Engineering Research Laboratory (CERL), and WES.

This volume contains the papers from Specialty Session F, State-of-the-Corps-Art on Stiffness Methods, Frames, and Military Construction. Mr. Donald B. Baldwin, General Engineer, DAEN-MCE-D, OCE, was session chairman and presented a paper. Other papers were presented by Mr. William D. Ashton, Chief, Structures Section, NCRED-D, Rock Island District; and Mr. Daniel Reynolds, Structural Engineer, SPKED-M, Sacramento District.

The Conference was successful due to the efforts of a multitude of people. The roles they played were different but they were all directed towards making a concept on "instant dissemination" work. The Organizing Committee for the Conference consisted of:

COL G. H. Hilt, WES
Mr. F. R. Brown, WES
Mr. D. L. Neumann, WES
Mr. J. B. Cheek, Jr., WES
Dr. N. Radhakrishnan, WES--Conference Coordinator
Mr. W. A. Price, WES
Mr. G. S. Hyde, WES
Mr. D. R. Dressler, LMVD
Mr. W. B. Dodd, LMNDE
Ms. E. Smith, LMNDE
Mr. L. H. Manson, LMNDE

An OCE Coordinating Committee also worked enthusiastically to

ensure the success of the Conference. This Committee consisted of:

Mr. C. F. Corns
Mr. R. L. Delyea
Mr. R. F. Malm, OCE Coordinator
Mr. L. G. Guthrie
Mr. D. B. Baldwin
Mr. R. A. McMurrer

The New Orleans District did a remarkable job in playing hosts to the Conference.

There were 13 division speakers, 25 moderators, two invited speakers, four technical speakers, and ten session chairmen, who shared the technical load of the Conference. Also, eight computer vendors showed their wares to the participants.

The editor would like to thank all the individuals who served on the committees and the speakers and the moderators for sharing their time and thoughts. Without them the Conference would not have been the success it was. Mr. Dressler, LMVD, and Mr. Price, WES, are specially thanked for their technical guidance and assistance.

This report was edited by Dr. N. Radhakrishnan, Research Civil Engineer, Computer Analysis Branch (CAB) and Special Technical Assistant, ADP Center, under the direct supervision of Mr. J. B. Cheek, Jr., Chief, CAB, ADP Center, and the general supervision of Mr. D. L. Neumann, Chief, ADP Center.

The Director of WES during the Conference and the preparation of this report was COL G. H. Hilt, CE. Mr. F. R. Brown was Technical Director.

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STIFFNESS ANALYSIS OF STRUCTURES

by

William D. Ashton*

Matrix analysis is an accepted method of analyzing structures in the Corps of Engineers. The application of matrix techniques in the solution of conventional design problems is increasing rapidly. Design staffs are using automated matrix design systems to produce superior designs in reduced time and at lower project costs.

The Corps of Engineers' designers first became involved in matrix analysis when the University of California made significant advancements in the analysis of two-dimensional continuums, commonly known as finite element analysis. The finite element methods are equally powerful analysis tools in the design of beams, trusses, and frames. These conventional structural systems are being analyzed with matrix analysis programs by numerous district design staffs. Recent advances in interactive graphics will make matrix analysis of 2-D continuums an accepted practice in the Corps of Engineers. This paper briefly summarizes the basic concepts and the coding procedures similar to all program packages. Much of the material presented has been obtained from the manuscript by W. D. Ashton and Dr. B. L. Meyers (Bechtel Corp.), "Stiffness Analysis of Structural Systems."

Available to the structural designer is a wide assortment of generalized matrix solution programs, such as STRESS, STRUDL, GENSAP, etc. Also available are many programs developed by various District offices, such as PTRUSS, GFRAME, BEAM, TRUSS, FRAME, GRID, STRUSS, etc. The available matrix programs make possible the analysis of continuous beams, plane pin-jointed trusses, plane frames, grid structures, and space trusses. The programs are based on the stiffness method of matrix analysis and the majority use direct stiffness techniques for solving the systems of equations for the displacements. In all the programs,

* Chief, Structures Section, Rock Island District.

the designer prepares an idealization of the structure to be analyzed and describes the engineering properties of each member along with the location of each nodal point in the structural system. The computer assembles the required properties of the total system into a representative matrix. The matrix is solved, and the engineer is provided with the displacements of each joint and the requested stresses in each member.

A designer requires time to gain confidence and to understand the computer program and its inherent assumptions and coding routines. Once a designer is familiar with a particular program package and is comfortable using it, he should continue to use it. Confidence, gained through repeated application, usually results in reduced design time and consequently realizes lower design costs. Each program has advantages and disadvantages, but each results in output consisting of displacements and stresses. Interactive graphics routines will soon be provided to simplify input and display output. Programs with interactive graphics capability will be favored by designers, and their use should be encouraged.

Simultaneous equations have been used for many years to express the relationships between forces applied to a structural system and the resulting displacements. Functional relationships can be written for any structure subjected to a set of forces. In the stiffness method the equations take the following matrix form:

$$[F] = [K] \{ \delta \}$$

where

$[F]$ is a column matrix representing the force system

$[K]$ is a square matrix of the stiffness coefficients

$\{ \delta \}$ is a column matrix representing the displacements

A structure can be considered a collection of elements of known stiffness behavior. The stiffness coefficients describing this behavior must be evaluated for a specific structural configuration (i.e. beam, truss, etc.) being analyzed, by satisfying the condition of equilibrium and strain compatibility, and the stress-strain law of the material. A single stiffness matrix can be constructed that will completely describe

the behavior of the structure. The equations represented by the stiffness matrix can be assembled in an efficient manner on the computer. The solution of the structural stiffness problem reduces to solving the matrix equation for the unknown displacements.

The stiffness matrix is square, positive definite, and symmetrical about the principal diagonal. The direct stiffness procedures permit solution for the unknown displacements directly, using the general stiffness equations. Modification and conditioning of the structural stiffness matrix are accomplished without destroying the banded symmetrical properties of the matrix. The direct stiffness method requires storage of only one-half of the symmetrical band of the structure stiffness coefficients, which results in a significant reduction in computer memory. This reduction in computer hardware requirements, combined with the application of direct matrix solution techniques, makes the direct stiffness method ideal for the analysis of large structural systems.

The advantages of the stiffness method become obvious as the engineer applies the procedures to increasingly complex structures. The simplicity, compactness, and generality in analyzing diversified structural behavior make the method ideal for the straightforward development of computer-aided design systems. The direct stiffness method permits realization of the advantages of computer-aided design from its initial introduction into the design system, and permits continuous growth to more sophisticated systems as the users develop and analyze more complex applications. Identical programming procedures, with slight modifications for structural type, are used in all direct stiffness applications, greatly reducing programming time and effort in the initial development and the learning time required by new users. Consequently, conversion of the programs developed within the Corps to available hardware involves routine programming procedures and a minimal engineering effort.

The input data required in all programs represent a numerical characterization of the idealization of the structural system. The input data for the majority of applications can be divided into the following categories:

Identification Data
Control Data
Material Properties
Nodal Point Description
Element Definition

The identification data should describe the problem being analyzed. Space is usually allocated for the engineer's name, project number, and structure identifiers. The responsible engineer should sign a listing of the computer input after review for correctness.

The control data are usually a single card transmitting the number of material cards, nodal point cards, and element cards which will be used to describe the structure. Using the data provided, values are inserted into computer memory establishing iterative limits in the computer routines.

In large structural systems consisting of more than one material, or in large framed structures where identical section properties are used for many members, separate blocks of material data are being used to advantage. Each material or structural shape is given a numerical code. These numerical codes index an area in the computer where data describing the particular material or section are retained. Each element is assigned the appropriate material code that matches its characteristics with those indexed on the material cards and in computer memory. In subsequent computer routines the program sequence seeks the index number for a particular element and uses the matching values in evaluating the stiffness characteristics.

An alternate method sometimes found is to specify the material description with the definition of each element. This procedure allows an unlimited number of materials to be used, but substantially increases the volume of input data to be prepared.

The required nodal point information is similar to the information necessary to accurately sketch the geometry, loading, and boundary restraints of the structural system. The geometric locations of each nodal point, in structure coordinates, must be determined along with the known loads or boundary restraints at each node. One card or line is

usually used to input these data for each nodal point. This input medium contains the list of coordinates, the load or displacements appropriate to each node, and a nodal point code number unique to the class of structure under consideration.

The nodal point code defines to the computer the type of boundary restraints or applied loads, if any, which are located at each node. The nodal point code is used in the computer routines which assemble the load vector and modify the appropriate equations in the stiffness matrix for boundary restraint.

Two basic nodal point codes are commonly used. The first is identical to the type code used on the material cards. The code assigns a number to each possible arrangement of restrained or unrestrained actions at a node.

When the number of permissible degrees of freedom permit numerous combinations, a digital nodal point code is more convenient. A code number containing a digit location for each permissible displacement action is used. If the displacement is restrained at the node being described as 1, it is entered in the corresponding digit location and the value of the restraint becomes an input value. If the particular displacement is permitted, a 0 is entered in the corresponding digit location and a force value becomes an input value.

Each element is defined to the computer using one input line or card containing the nodal point numbers of the element and a material index code or a listing of the material properties. Knowing the nodal numbers which define the element boundary, the computer can retrieve the associated nodal coordinates from the nodal point description. The order of specifying the node numbers is immaterial to the analysis except in describing the finite element, which is usually specified in a counterclockwise manner.

The first step in the computer program must allocate appropriate sized blocks of storage in computer memory for retention of various subscripted variables, such as stiffness coefficients, used throughout the program. The size of each block depends primarily on the following characteristics of the system: (a) number of degrees of freedom,

(b) number of nodal points permissible, (c) number of elements permissible, and (d) solution technique.

The number of degrees of freedom is established by the class of structure. The number of nodal points and number of elements is different for each structural application. The initial programmer must select a combination of nodal points and elements representative of the type of problems to be analyzed. The engineer must be aware of this arbitrary decision and modify the appropriate storage specifications as required for special element-nodal point connectivity. In large packages the storage specifications are made very large, so that only very infrequently will an application arise that the system cannot handle without modification. Unfortunately, such liberal assignment of storage specifications must also be paid for in the solution of the small frequently encountered problems.

Continued and more intensive training is required to insure the correct use of matrix analysis programs. Training disseminates information regarding program application and aids in overcoming the natural reluctance to use automated design techniques. Management should encourage the evolution of computer-aided design with training. In-house programs frequently are more easily understood, operate at greatly reduced costs, and provide the basis to develop a thorough understanding of more sophisticated techniques.

COMPUTER-AIDED DESIGN FOR BUILDING FRAMES

by

Daniel W. Reynolds*

Present State of the Art

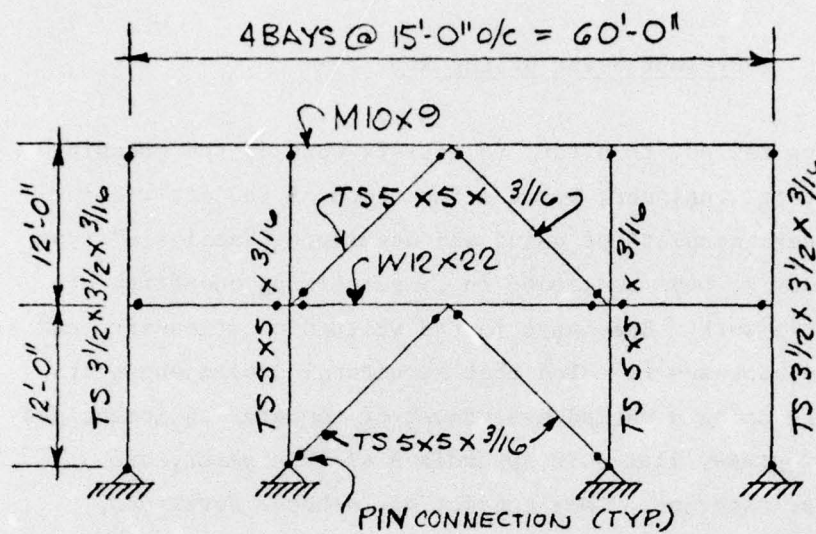
Computers have failed, thus far, to satisfy some of the pressing needs of the structural engineer, because the state of the art within the Corps of Engineers consists of using and developing "analysis" type programs, which means we have succeeded in computerizing one-fifth of the design engineer's work. Responses to the written questionnaire and follow-up telephone canvases revealed that structural design engineers within the Corps are using a varied assortment of computer equipment and programs. These programs, listed in Appendix A of this paper, are mainly analysis type programs. They consist of in-house developed, documented, and undocumented programs, university research sponsored, single and general purpose programs and programs available through contracted computer services. For analysis type programs, the engineer describes structure geometry, loads and assumed member sizes, and uses the computer to perform indeterminate frame analysis. The analysis represents about 20 percent of the total design procedure.

An example two-story, two-dimensional steel-frame problem, Figure 1, was sent to different districts for solution by engineers experienced with using the various programs available. The results are included as Appendix B of this paper for your comparison of the different programs, and as an example of the present computer-aided design art within the Corps of Engineers.

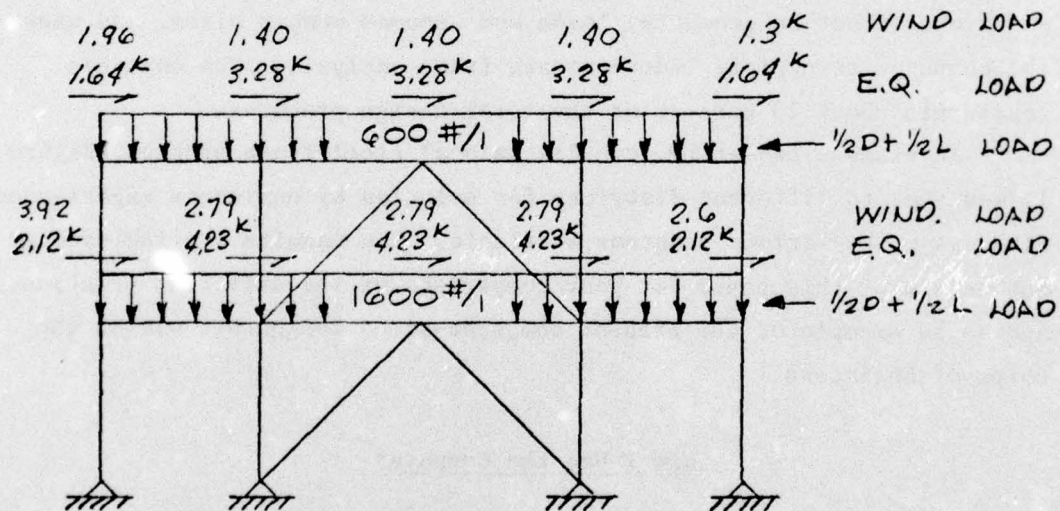
How I Use the Computer

In my district, the designing of 2-D and 3-D frames is now limited to the use of analysis type programs, such as Wilson 2-D Frame, SAP IV,

* Structural Engineer, Military Design Branch, Sacramento District.



FRAME ELEVATION



FRAME LOADS

Figure 1. Steel frame problem used in solution programs of Appendix B

and GENSAP. Most of the work is being done with SAP IV; we feel that using SAP IV, even on small structures, is warranted in order to stay confident and efficient using the program. All programs are run in the remote batch mode. All preanalysis processing for input data and post-analysis processing for design is done by hand calculator and the Wang 700B programmable calculator. The three example structures done in my district on the computer are: (a) the Post Chapel Addition at the Presidio of San Francisco, California, (b) the Weapon Evaluation Facility at Yuma Proving Grounds in Arizona, and (c) the Dental Clinic at Fort Ord, Monterey, California.

Figure 2 shows the interior of the Post Chapel at the Presidio of San Francisco. It was built around 1889 and went through the 1906 San Francisco Earthquake. We extended the Chapel and added one new frame to match the existing ones, which were made of 4 by 8 timber beams. This is an indeterminate frame; there is no tension rod between the center (of the) top and bottom chords and every member is bending. A year after the building was completed the new frame had deflected noticeably and repairs were required.

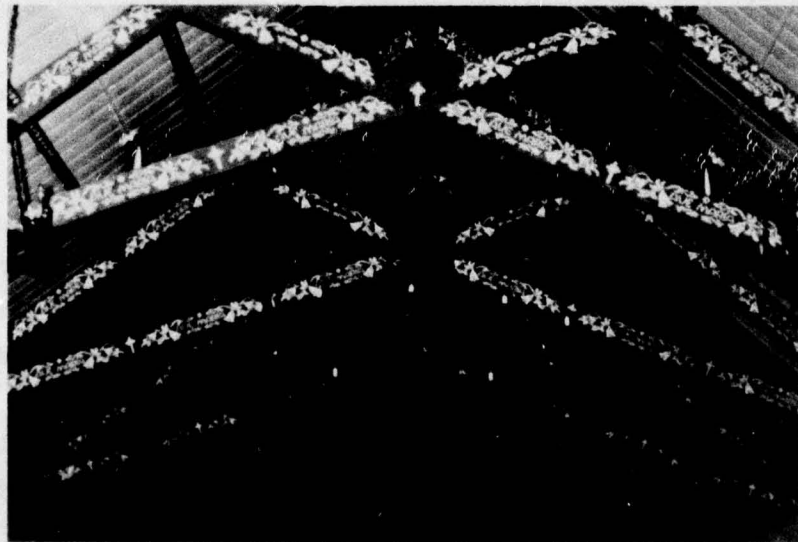


Figure 2. Interior of Post Chapel

Figure 3 shows part of the contract drawing of the process we used to repair the deflected frame. We jacked the frame up, using 370-lb force at five panel points simultaneously, thus restoring it to its original undeflected shape. Then we added a chain between the top and bottom chord panel center points to take tension (Figure 4) thus making the frame a truss, which was stronger and deflected less. Chain was used as the tension member to match the existing chapel decor.

Figure 5 is a computer model used to determine the forces and match the deflected shape of the frame. Four such models were tried before the deflected frame was matched. The input model (straight lines) used continuous members with pinned joints except for the half-lapped joint at the center bottom chord connection. The forces were input using fixed-end forces through the top chords. The deflected frame (curved lines) and the member end forces were now used as input for the next computer model. Note the direction of the member end moments.

Figure 6 is the final computer model showing the five jacking forces used to restore the frame to its original position (straight lines). Note that the member end-moments have reversed, thus relieving the member forces induced by the deflection. The Wilson 2-D Frame program was used. Note that pinned ends were required in order to match the existing deflected truss and two materials (steel chains and timber beams) were required to solve the problem.

Figure 7 illustrates the end elevation of the Weapons Evaluation Facility at Yuma, Arizona. The building is 300 ft square and 50 ft high.

Figure 8 shows the building in cross section with three spans of 55 ft and one of 90 ft. There is a 40-ton bridge crane in the high bay and 10-ton bridge cranes in one of the 55- and the 90-ft bays. This building would be very difficult to analyze without the aid of the computer.

Figure 9 shows one 55-ft bay. The high bay is to the right of the figure. Note the cars in the lower right-hand side of the figure in relationship to the building size.

Truss T-5, which is symmetrical about its center line, is shown in

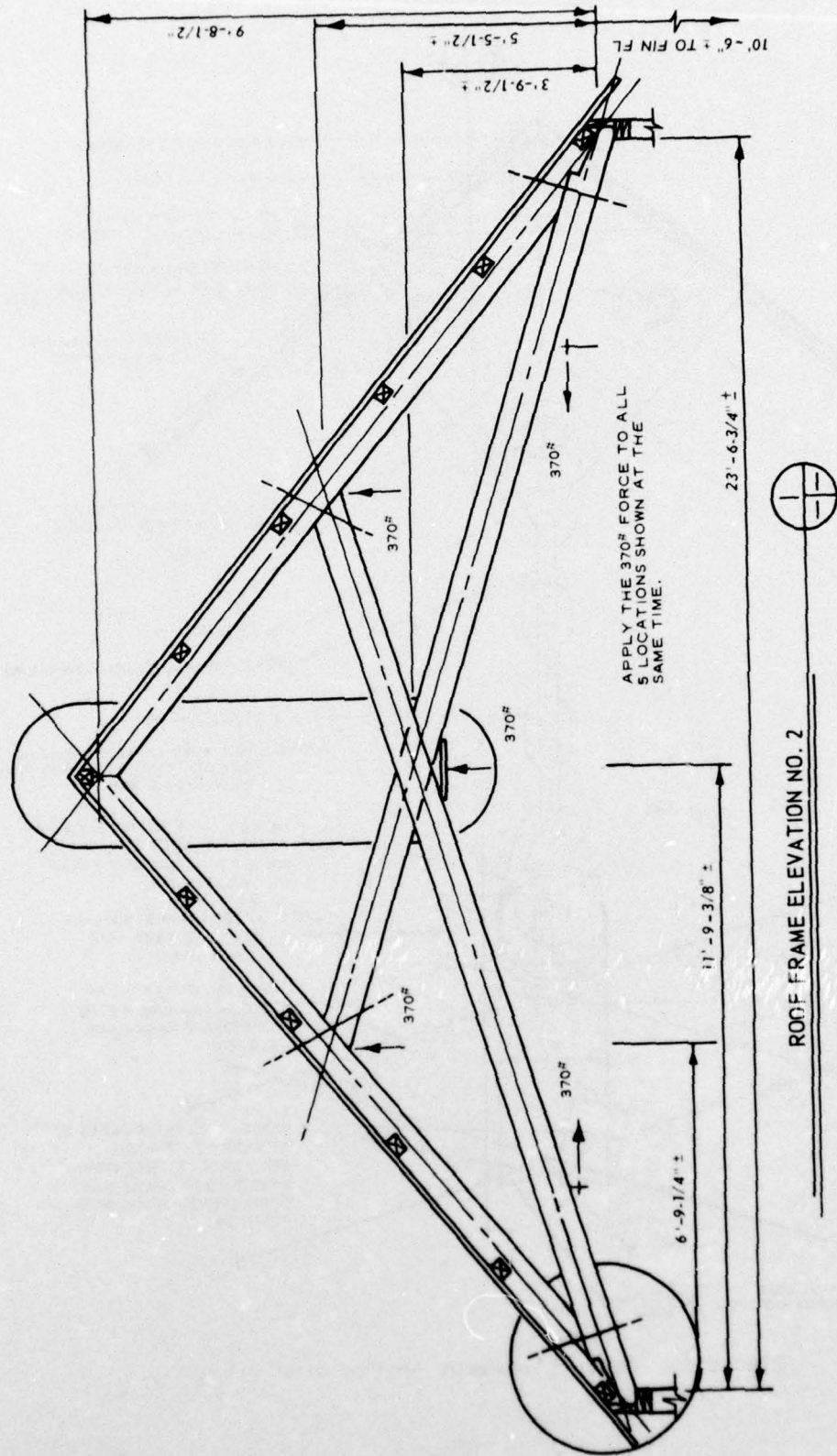


Figure 3. Contract drawing of process used in frame reparation

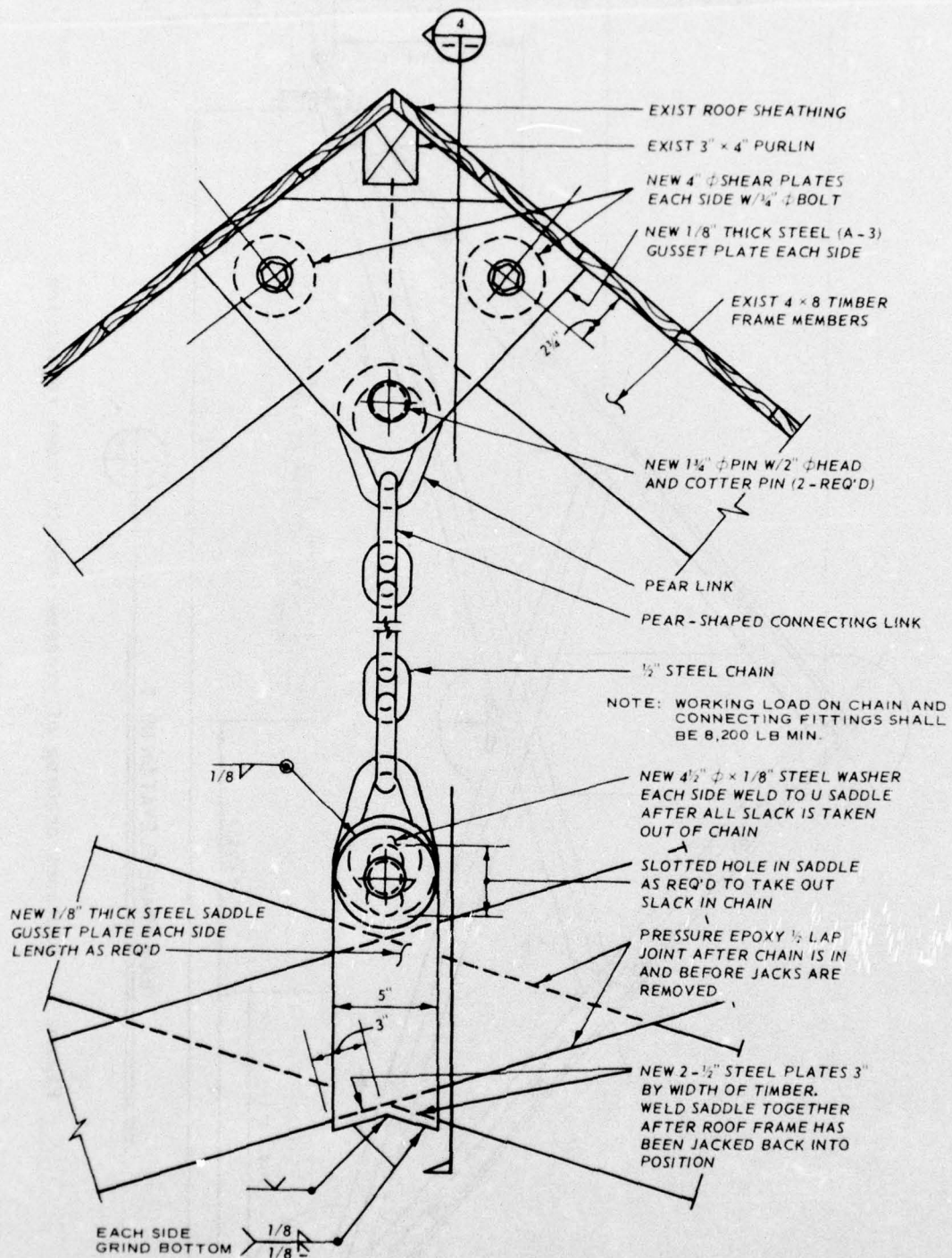


Figure 4. Chain placement on restored frame

ELEMENT	MEMBER END FORCES					
	AXIAL I	SHEAR I	MOMENT I	AXIAL J	SHEAR J	MOMENT J
1	1.060	0.325	0.000	-1.404	0.139	14.773
2	0.622	-0.081	-14.773	-0.378	0.347	0.000
3	-1.176	0.135	0.000	1.216	-0.45	14.078
4	0.562	0.694	0.000	-0.375	-0.666	14.268
5	0.374	-0.666	-14.268	-0.362	0.694	0.000
6	0.376	0.347	0.000	-0.622	-0.091	14.773
7	1.404	0.139	-14.773	-1.066	0.365	0.000
8	-1.216	-0.045	-14.078	1.176	0.135	-0.00
9	-1.217	0.004	-14.078	1.217	-0.04	14.097
10	0.309	0.652	-14.268	-0.399	-0.652	14.773
11	0.309	-0.652	-14.097	1.217	0.652	14.078
12	-1.217	-0.004	-14.097	1.217	0.004	14.078

$$(14.773)(1000) = 934.5 \text{ psi} \cdot \text{ok}$$

$$(37.823)(1000) = 2225 \text{ psi}$$

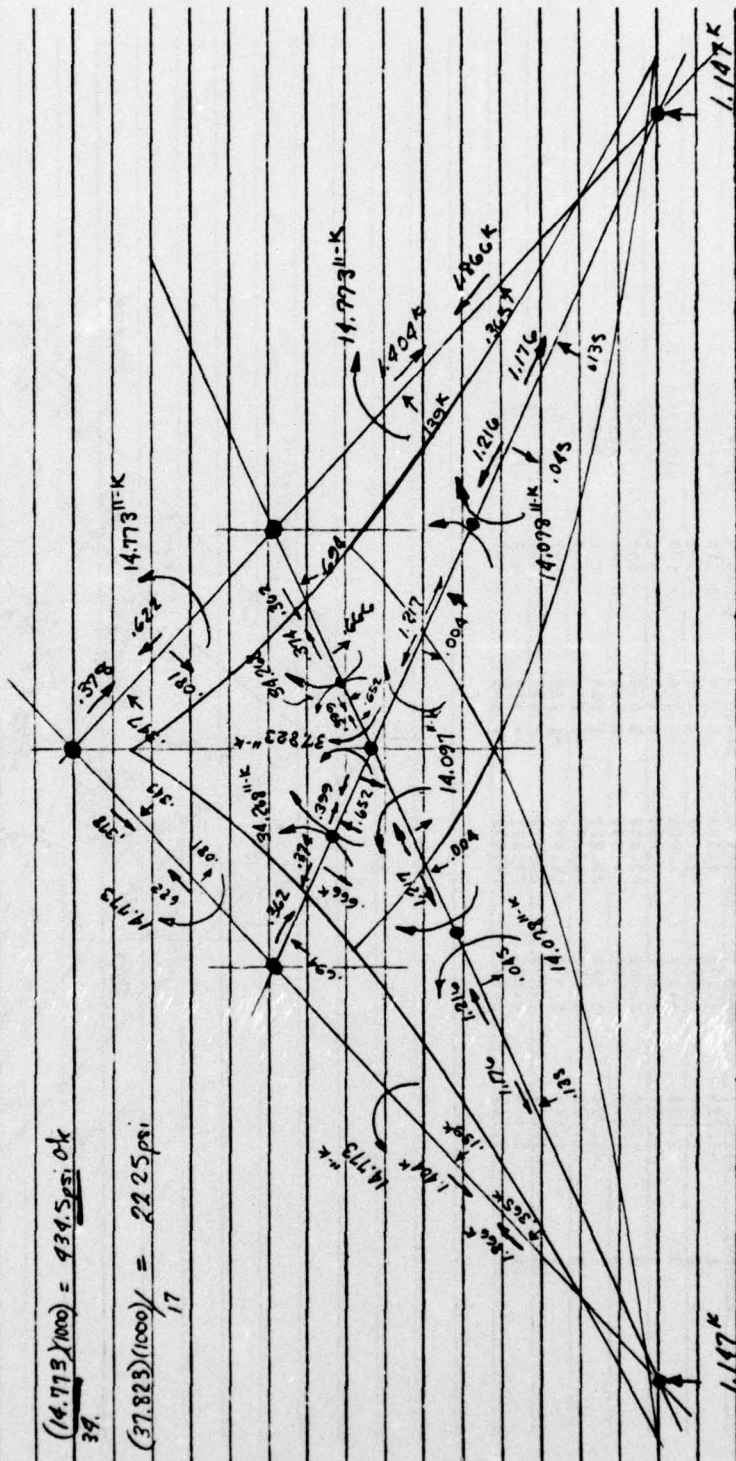


Figure 5. Trial computer model of deflected frame

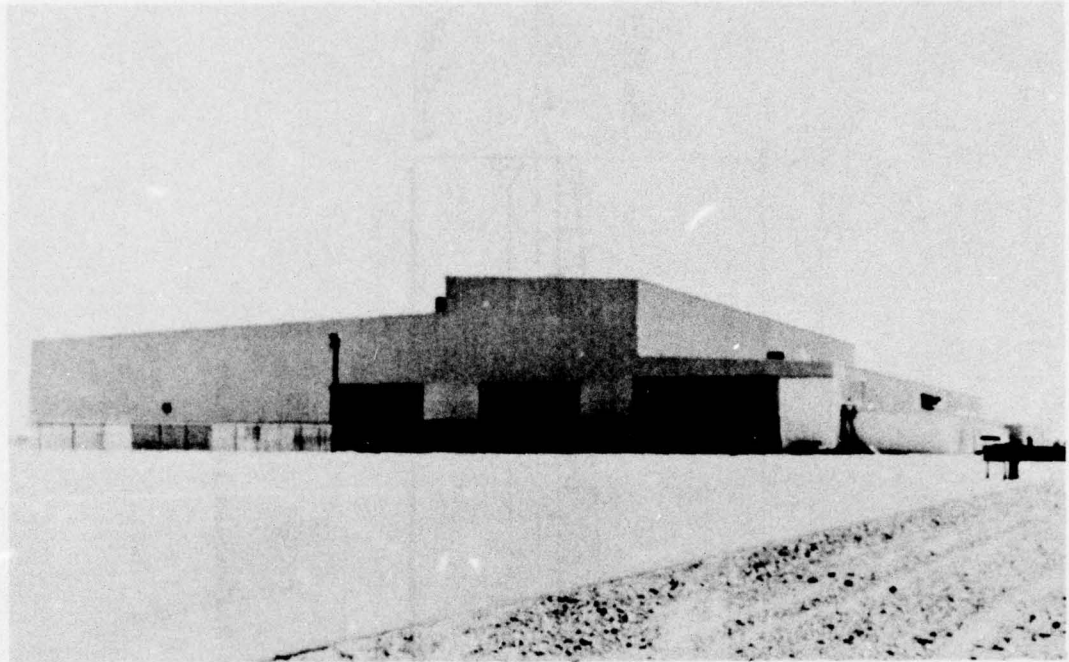
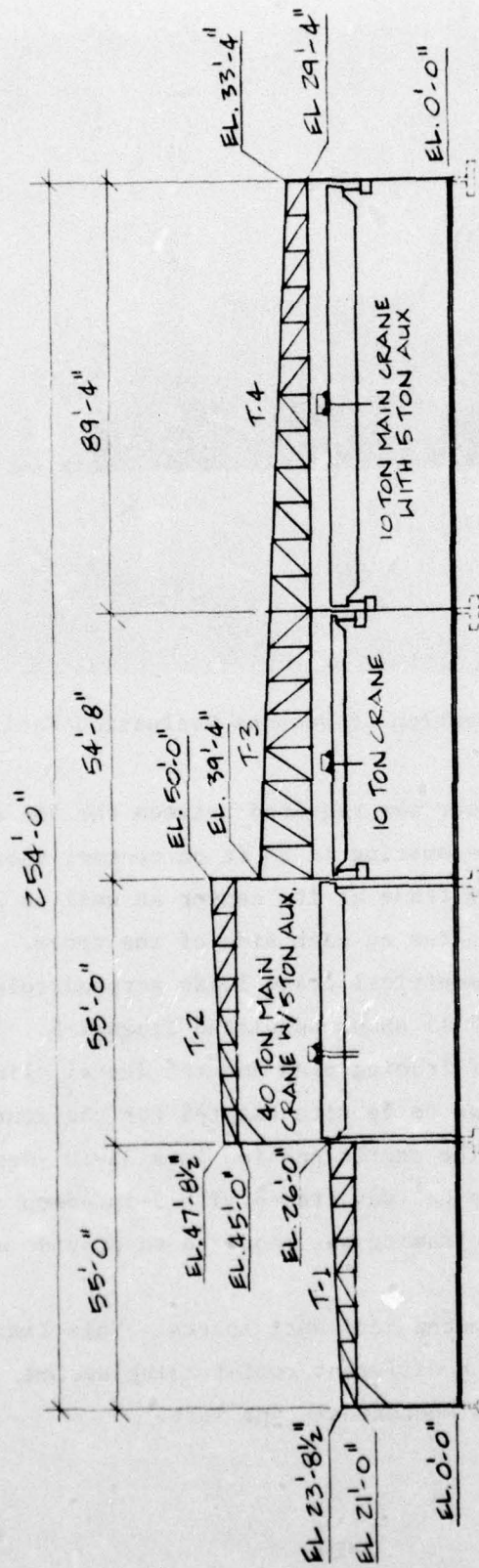


Figure 7. End elevation of Weapons Evaluation Facility

Figure 10. A 40-ft-wide door was required between the 55- and 90-ft bays. The regular building column spacing is 25 ft on center; therefore Truss T-5 must support a building frame at its center as well as a 10-ton bridge crane of different span lengths on each side of the truss. This required a 3-D analysis due to unsymmetrical crane loads perpendicular to the plane of the truss. Figure 11 shows completed Truss T-5.

Figure 12 is the roof framing plan for the dental clinic at Fort Lewis, Washington, which was to be site adapted for the dental clinic at Fort Ord, California. The center portion is a 36-in.-deep open web joist. Down each side is a hallway framed with 3-in.-deep channel sections. The change in roof framing was required to provide a mechanical duct space.

Figure 13 shows the mechanical duct spaces. This limited space prompted me to investigate a different roof-framing system, one which was deep enough to act as a mechanical-type loft.



TRUSS ELEVATION

Figure 8. Cross section of Weapons Evaluation Facility



Figure 9. 55-ft bay of Weapons Evaluation Facility

Figure 14 is a cross section of the new roof framing system and the mechanical duct space provided.

Figure 15 is a picture of a section of the new roof framing system, a 3-dimensional space truss.

Figure 16 illustrates a 3-dimensional space truss made of double angle top and bottom chords and bent pipes for diagonals; 2-in. square tubes were used as transverse top and bottom chords.

Figure 17 shows the uniform 4-ft by 8-in. depth of the 3-D space truss, which provides for the mechanical loft. This roof framing system would not have been considered if it were not for the computer program SAP IV. The roof system is symmetrical about both center lines. Therefore, only one fourth of the structure was modeled.

The computer model contained 252 modal points and 647 members. Therefore, in order to verify the input data, it was plotted by a Cal Comp Plotter using a plotting subroutine in the program GENSAP.

The estimated cost of the original roof framing system was \$96,000.

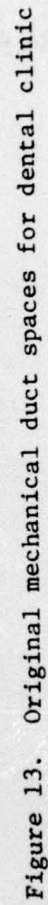


Figure 11. Truss T-5 completed

The estimated cost of the 3-D space truss system was \$71,200; this represented a \$24,800 savings. After deducting the value engineering study cost of \$3000 and the \$3000 redesign cost, the net savings is \$18,800.

These three examples have shown the change in design philosophy within my district, from the use of the computer to solve a difficult repair job, to the design of a complicated conventional 2-D frame, to a unique structural solution for meeting a functional requirement without regard for limitations set by analytical methods.

The computer-aided design procedure just illustrated is adequate in concept, but contains deficiencies in practice. For example, as stated before, the GENSAP program is used for plotting because SAP IV does not have a plot subroutine. Therefore, input data must be changed to run on GENSAP; at this time the job card deck is transmitted through a COPE 1200 terminal from the District ADP Center to Lawrence Berkeley Lab (LBL) at Berkeley, California. There it is run on a CDC 7600 Computer, which generates a plot tape. The plot tape is taken by courier to the division



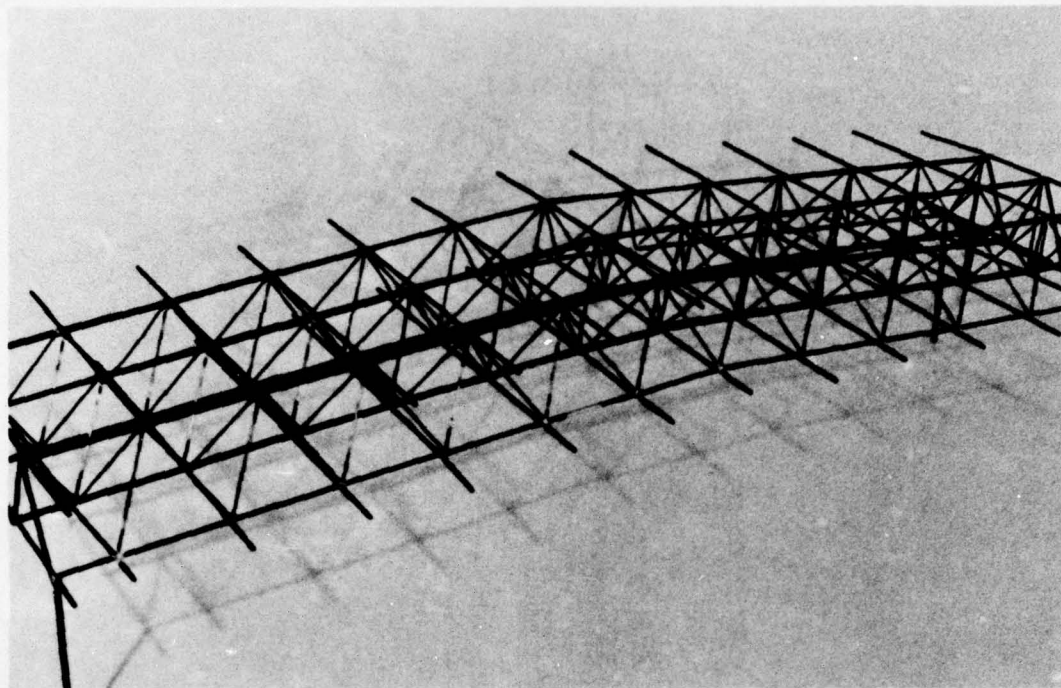


Figure 15. 3-D space truss model for dental clinic

ADP Center to be plotted on a Cal Comp Plotter. The plot is then sent by courier to our district. This plotting procedure takes a minimum of two complete working days; if there are any errors in the input data, the procedure is repeated until the input data are verified.

We have informed our ADP Center of this inconvenience and have requested that they install a plotter in the district. We have also informed them that a plot program is available for SAP IV from an outside vendor, but nothing has been done to improve the situation. I feel that this example of inadequate program and equipment support, resulting in lost effort and time, and generating ill will between designer and supervisor, is typical of the problems other districts are having with computer-aided design.

Restraints Placed on Computer Usage

The inefficient and slow progress of computer-aided design within

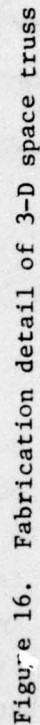
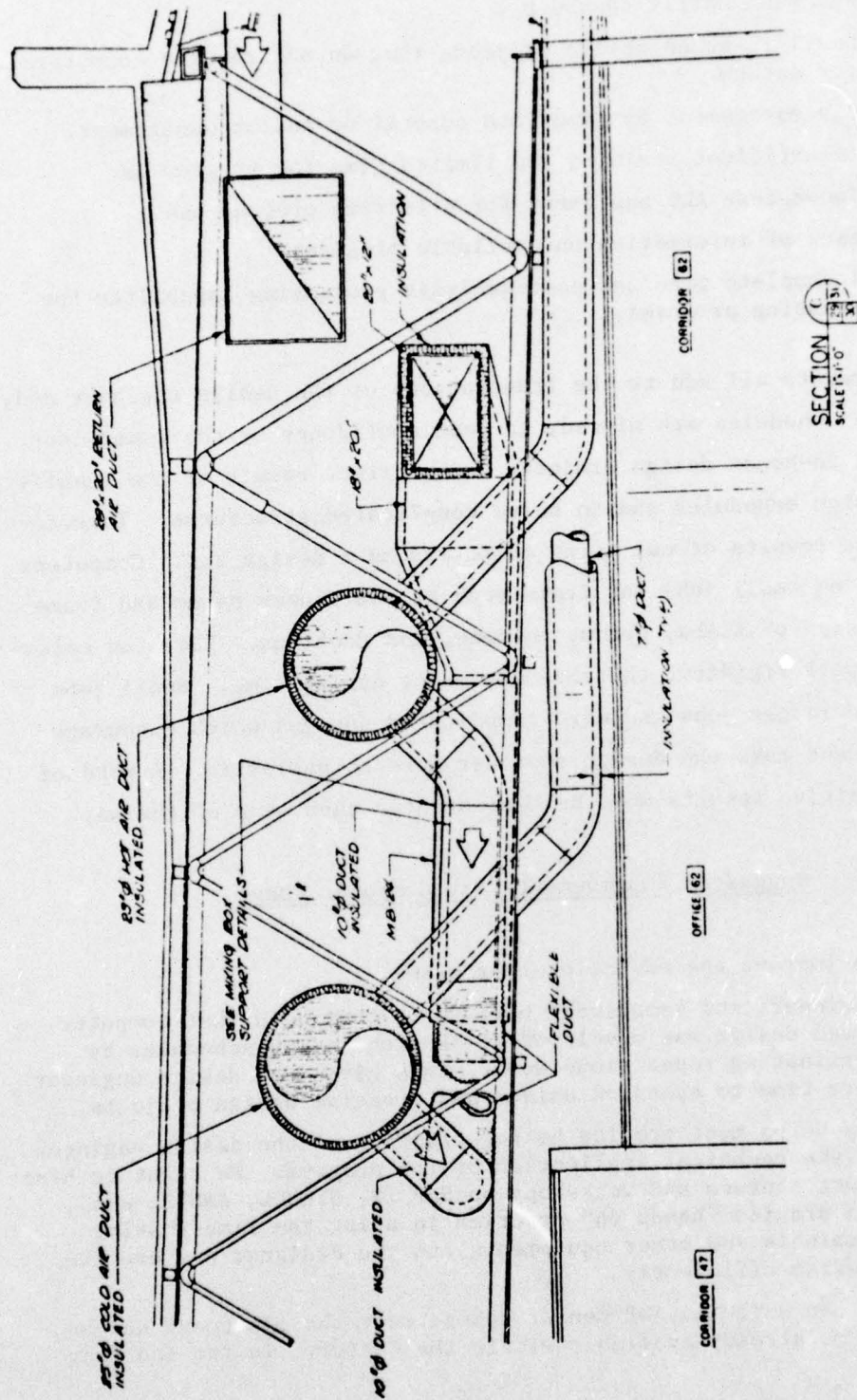


Figure 16. Fabrication detail of 3-D space truss



NOTE
SECTION SHOWN IS TYPICAL FOR CONNECTION FROM
ACT & CED DECKS TO MIXING BOX FROM MIXING
BOX TO SUPPLY DUCTS & SUPPLY DIFFUSERS
AND FROM RETURN AIR DUCTS & REGISTERS TO
RETURN AIR MAIN.

Figure 17. Cross section of dental clinic roof framing with ductwork installed

the Corps has been partly caused by:

- a. Small in-house design projects that do not require computers for design.
- b. Discouragement by immediate supervisor and/or management.
- c. Insufficient training and limited time for program use.
- d. Incomplete ADP equipment for effective program use.
- e. Lack of information on available programs.
- f. Incomplete pre- and post-analysis processing capability for existing programs.

These restraints all add to the frustrations of the design engineer and, when design schedules are missed, to lost confidence by the supervisor.

Small in-house design projects are a direct result of the inability to meet design schedules and to solve complicated structures. Therefore, they are the results of not using computers as a design aid. Computers can be used on small jobs for items such as continuous beams and frame moments, design of slabs, beams, columns, and footings. They can calculate shear wall rigidity, thereby shortening design time. Small jobs then lead to larger jobs and more complicated designs which encourage better work and make the design engineer more enthusiastic. A word of caution, positive results must be demonstrated each step of the way.

Suggested Improvements for Computer Usage

We can improve the educational programs.

- a. Engineers and management have to be convinced that computer-aided design was developed to shorten design schedules by eliminating repetitious work. This gives the design engineer more time to spend on unique and creative design projects.
- b. The Corps must provide better training of the design engineer in the technical application of the program. We ought to have short courses and workshops on SAP IV, STRUDL, ANSYS, etc., and provide "hands on" practice in using the time-sharing terminals and other equipments, so the designer can use the program efficiently.
- c. We can have the ADP Center demonstrate the equipment and programs already available within the Center. In far too many

cases, the districts already have capabilities which the designers are not using.

- d. We need to have demonstrations by vendors and in-house organizations to expose management and supervisors to available computer-aided design techniques and equipment and to present an overview of new approaches to existing engineering problems.

We can evaluate what ADP equipment and services are needed by the district for effective program usage and take action for their procurement. We need:

- a. Graphic terminals or Cathode Ray Tube Terminals (CRT), which are television type screen units used for input and output in time-sharing program usage.
- b. Graphic input devices for generating input data. A graphical device is generally an electronic light table with an electronic pencil or mouse for tracing a drawing and converting its information into numbers for use by the computer. Its use can accelerate the input of frames and finite element grids.
- c. Flat bed or drum plotters for plotting input and output for such items as deflected shapes, principal stresses, stress contours, schedules of member sizes, and reinforcing steel bars, etc.
- d. Contracts with outside vendors' services such as MCAUTO (McDonald Douglas Automation Company), BCS (Boeing Computer Services, Inc.), SDRC (Structural Dynamics Research Corporation), CDC (Control Data Corporation), etc.

We can expand the Engineering Computer Program Library (ECPL) and their listing of accepted programs.

- a. The library should maintain a listing of programs which are currently under development, because many programs are being written and not documented due to lack of time and funds.
- b. The library should promote official and unofficial channels of communication between designers and districts for sharing ideas and programs. The "Engineering Computer Notes" published by WES is one method of communication. Another method is to designate computer-oriented design engineers as ADP design coordinators in each district (similar to present coordinators in ADP Section).

We can determine programs needed within the district's set priorities and start developing or procuring them.

Although many programs are available to structural engineers, their usefulness is diminished by the varying standards to which they are

written, the many different forms of input data, and the machine-dependent nature of the programs. Each program should be designed with a common data basis and as a subprogram so that they can be linked together and tailored by the engineer developing a systems approach to meet the requirements of the particular structure under design. A list of such subprograms is as follows:

a. Preanalysis programs.

- (1) Graphic package to generate input data and plots.
- (2) Programs to generate fixed-end force data for input into the analysis programs.
- (3) Programs which calculate assumed member sizes for input data.

b. Analysis programs. What should a good 2-D frame analysis program have?

- (1) Option for prismatic and/or nonprismatic cross section.
- (2) Option for variable stiffness, rigid, or pinned joints.
- (3) Option for rigid or yielding supports.
- (4) Option for combining members with different moduli of elasticity.
- (5) Method for generating loading combinations including: dead loads, live loads, wind loads, earthquake loads, and temperature loads.
- (6) Method for generating input data such as nodal points, members, loadings, etc.
- (7) Option for shear and axial force deformations.
- (8) Output that echoes print input data for verification.
- (9) Output that includes deflections, axial forces, shear forces, moments, and reactions, printed out under non-symbolic heading.
- (10) Generation of a stored data file for data recall for use by postanalysis processing programs.
- (11) Output format easily reproduced and used as the design analysis.

c. Postanalysis processing programs.

- (1) Programs to produce graphic output including such items as:
 - (a) Deflected structure.
 - (b) Principal stress for plate and shell elements.

(c) Mode shapes.

- (2) Programs to convert distributed moments, shear forces, and results of the analysis program, and to calculate the positive moments, shear forces, points of inflection and deflections.

d. Design programs.

- (1) Design programs should take the analysis and postanalysis program results and design the beams, columns, connections, and footings according to building code requirements. Output for these programs should be as complete as possible, including schedules for all types of members and a complete tabulation of material quantities for estimating. The format should allow these schedules to be copied directly onto contract documents by draftsmen or transferred by other means. Many of these programs are already developed; however, they have to be linked with each other in order to obtain the complete analysis and design program.
- (2) The ICES-STRU DL system is the only complete analysis and design program available for designing frames within the Corps of Engineers library. This program is available to the districts within the North Pacific Division and through a vendor contract at the Waterways Experiment Station (WES) to a limited number of other districts.
- (3) The long-range approach to design programs must consider construction economy. Construction cost is of utmost importance in both civil and military construction; therefore, construction cost should be one of the controlling design factors. All programs we have discussed are for analyzing and designing structures to conform to allowable stresses and design codes with no references to cost except for a tabulation of material quantities for estimating. The computer-aided design approach must have an optimization procedure for determining the most economical combination of materials for construction. For example, to produce the lowest cost reinforced concrete members, the optimum relationship between the member capacity and the combination of two materials having different relative costs and strengths must be determined.

In conclusion, the state of the art within the Corps of Engineers consists of using and developing analysis programs, which represent about 20 percent of the design engineer's work. In order to realize the full potential of the computer it is imperative that we develop economical methods for using the computer in solving the full range of structural problems. It is felt by many that we are at a turning point in computer

usage for structural engineers within the Corps. The next few years will see substantial progress in developing a unified and positive approach to computer-aided design.

Appendix A: List of Computer Programs

TRUSS ANALYSIS PROGRAMS							
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER-- OCE CATEGORY	COMPUTER/ MODE	DOCUMENTED		DESCRIPTION
					YES	NO	
PTRUSS (Program in progress)	Memphis District		713-09-A1050	G-635	X		Solution of joint displacements and member axial load for planar pinned trusses.
X0002 (TRUSS)	Rock Island District	WESLIB	713-F3-F401B	G-635	X		Plane pin-jointed truss analysis by direct stiffness. Total truss structure stiffness is assembled from individual truss bar stiffness matrices. Then equation and terms related to known boundary conditions are modified. Data can be entered interactively or from a data file.
X0005 (STRUSS)	Rock Island District	WESLIB	713-F3-F401E	G-635	X		Pin-jointed space truss by direct stiffness. Space structures composed of members which are assumed straight between joints with loads applied at joint only and whose ends are free to rotate are considered. Individual bar stiffness matrices are determined by a modified gaussian elimination procedure.
Determinate Truss	David Heindel, USAE District, Norfolk, Baltimore	ECPL	713-F7-E4580 B	G-225 Batch	X		"Determinate Truss Analysis" of a simple statically determinate pin-connected truss for the support reactions and axial stress in up to 425 members. Loads are applied at joints.
Pin-Jointed Truss Analysis	Ploudre, Seattle District E. Wilson U.C. Berkeley	NPD	713-K5-G3150 A	IBM 360	X		2-D truss using direct stiffness method including support settlement.
Truss Influence Lines Plot	Ploudre, Seattle District	NPD	713-K5-G327 A	IBM 360	X		Modified pin-jointed truss analysis. Program 713-K5-G3150 is used for plotting influence lines.

CONTINUOUS BEAMS - ANALYSIS PROGRAMS							
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER-- OCE CATEGORY	COMPUTER/ MODE	DOCUMENTED		DESCRIPTION
					YES	NO	
MDCF	W.A. Price, WESKA	WESLIB	713-F3-M3500	600TSS	X		Moment distribution for prismatic members. The program computes fixed-end moments, fixed-end shears, simple-span shears, and equivalent-FEM trapezoidal load for any superimposed combination of point loads and trapezoidal loads, over any portion of the span.
X0001 (BEAM 1)	Rock Island District	WESLIB	713-F3-F401A	G-635	X		Analysis of beams by direct stiffness method. The computer program analyzes beams of variable cross sections subjected to arbitrary loading. It uses the principle of matrix structure analysis, using the displacement method. Data can be entered interactively or from a data file.
BEAMHBW	H. B. Wilson, University of Alabama			G-635	X		General purpose continuous beam analysis. Multiple span, variable section properties, point and trapezoidal loads are computed. Plots shear, moment, slope, and deflection are given on terminal printer.
GIRDER	Paul Senter, WESKA	WESLIB		600TSS	X		Load Analysis Program. GIRDER provides an analysis of the loading (reactions, shears, and bending moments) in continuous girder in up to five spans using the principle of least work.
BMCOL	Professor Matlock, University of Texas Dr. N. Radhakrishnan, WESKA	LMVD		600 Card-in	X		Finite difference program to solve a variety of simple and complex beam-column structural problems accounting for movable loads.
BMCOL 4	Professor Matlock, University of Texas Fleming, Vicksburg District			GE-225 Batch	X		Linear finite difference program to solve a variety of single and complex beam-column structure problems.
/Mudd/BMCOL	Larry Farmer, Thomas Mudd, Saint Louis District	WESLIB	713-F3-A350	600TSS	X		Matlock's solution for BM-COL. The program is a finite element model solution for beam columns consisting of interacting bars and springs. It can model beam columns of varying cross section, applied lateral and axial loads, specified deflection and slopes, and lateral and rotational spring restraint.

CONTINUOUS BEAMS - ANALYSIS PROGRAMS							
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER-- OCE CATEGORY	COMPUTER/ MODE	DOCUMENTED		DESCRIPTION
					YES	NO	
A71350	Larry Farmer, Joe Vennari, Saint Louis District	WESLIB	713-F3-A350	600TSS	X		Matlock's recursive solution for beam columns. This program solves beam-column problems with Matlock's recursive solution.
MATLOCKM	Forms-Hartman, Joseph P. Hartman, Saint Louis District			600 Batch	X		Determines maximum positive and negative moments, shear displacements, and reactions at each location on a beam for any set of vertical load moved incrementally along the length of a beam. This is a modified version of BMCDL for moving loads.
BEAM	Dr. N. Radhakrishnan, WESKA	WESLIB		600TSS	X		Program to compute beam moments and deflections. This program computes moments and deflections in a single-span variable-depth beam carrying concentrated and distributed loads. The end deflections are zero. The remaining conditions can involve zero slope or zero moment.
BEAMNOD (Program in progress)	New Orleans District		713-F3-A2580	G-635	X		Analyze a symmetrical straight member for any statically determinant one-dimensional load which consists of transverse point loads, transverse continuous loads, or couples.
Beams (Shear, Moment, Deflection)	Beer, New Orleans District		713-F3-A2-580 C	600TSS		X	Determines for small deflections the shear force, bending moment, and deflection at selected positions for any statically determinant beam and coplanar loading perpendicular to the neutral axis. The program accepts a load system from 741-F3-A2-370 of WESLIB.
Finite Difference Analysis of Beam-Column on Elastic Foundation	Weller, Portland District	NPD	713-K5-G4130 A	IBM 360	X		
Beam Column Analysis w/ Printer Plot	Mueller, Dickenson, University of Missouri	NPD	713-K5-G2160 A	IBM 360	X		
Analysis of Curved Continuous Beams	Gniewosz Portland District	NPD	713-K5-G2210 A	IBM 360	X		

2-D FRAME ANALYSIS PROGRAMS							
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER-- OCE CATEGORY	COMPUTER/ MODE	DOCUMENTED		DESCRIPTION
					YES	NO	
WILSON 2-D	Ed Wilson, J. D. Rafferty, University of California, Berkeley, San Francisco District	ECPL	713-G2-L3002 B	IBM 360 Batch	X		Analysis of two-dimensional frame structures. Joint deflection, member-end forces, and joint reactions are determined for plane frames which may be subjected to joint loads, joint displacements, and member loads. Supports may be rigid or linear. Elastic members may be nonprismatic. Member to joint connections may be flexible (partially rigid). Different material may be used for different members in frame.
	D. Reynolds, Sacramento District		713-G2-L2-170 713-X6-L2-170	GE-415 CDC 7600 LBL Batch			
	Omaha District						
GFRAME	Robert Brittain, Memphis District	WESLIB	713-F3-A104	600TSS	X		Analysis of Planar Rigid Frames. The program analyzes planar rigid frames taking into account axial deformations.
GFRAME	Galveston District	ECPL	713-G1-A1040	G-225 G-437	X		Same program as GFRAME in system WESLIB, except links to program POSMO (713-G1-M3180) to compute shears, moments and axial forces at 1/10 points along each member of the frame for each load condition. The program uses rigid frame analysis with 60 members and 40 joints maximum.
X0003 (FRAME)	Rock Island District	WESLIB	713-F3-F401C	G-635	X		Analysis of frames by direct stiffness method. Computer program analyzes frames of variable cross section subjected to arbitrary loading. It uses the principle of matrix structure analysis, using the displacement method. Data can be entered interactively or from a data file.
X0004 (GRID)	Rock Island District	WESLIB	713-F3-F401D	G-635	X		Grid analysis by direct stiffness. The individual grid element stiffness matrix is transferred to the grid structure coordinate system and modified for specified boundary restraints. These restraints are added to form total structure stiffness matrix. Data can be entered interactively or from a data file.

2-D FRAME ANALYSIS PROGRAMS							
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER-- OCE CATEGORY	COMPUTER/ MODE	DOCUMENTED		DESCRIPTION
					YES	NO	
Grid Analysis	Portland District	NPD	713-K5-G2130 A	IBM 360	X		
FRAME (Program in progress)	Robert Hall, WESKA	WESLIB		G-635TSS Interactive Graphics	X		An interactive graphics program that builds frame cases and analyzes with GFRAME and displays shear, moment, and displacement diagrams.
	Vicksburg District		713-F3-A4140				Two-dimensional frame analysis program.
SM 468	Fleming, Vicksburg District		713-G9-A4020	400 Batch	X		Plane Frame - Beam element finite element code.
OFRAME	Robert Brittain, Memphis District	ECPL	713-G9-A1030 B	GE-400TSS	X		Analyzes planar orthogonal frames.
STRESS	Dr. N. Radhakrishnan	Honeywell		BATCH	X		Structural Engineering System Solver. Performs linear analysis of elastic statically loaded framed structures.
Indeterminate Frame	Brammer, Portland District	NPD	713-K5-G4100 B	IBM 360	X		
2-D Frame Analysis	McDonald, Portland District	NPD	713-K5-G4110 A	IBM 360	X		
Truss, Frame, & Beam Element Analysis	Mueller, Portland District	NPD	713-K5-G204A A	IBM 360	X		
Stiffness Analysis	Raisanen, Portland District	NPD	713-K5-G0030 B	IBM 360	X		
Lateral Force Distribution for Shear Walls	Lonberg, Portland District	NPD	713-K5-G2180 A	IBM 360	X		
Lateral Load Analysis of Multi-story Frames with Shear Walls	Ploudre, Portland Cement Association program	NPD	713-K5-G332 A	IBM 360	X		

3-D FRAME ANALYSIS PROGRAMS						
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER--OCE CATEGORY	COMPUTER/MODE	DOCUMENTED YES NO	DESCRIPTION
SAP IV	B. Haavisto, D. Reynolds, University of California Sacramento District	Sacramento District	713X6L221A	Batch/CDC7600 @ LBL	X	General finite element program for static and dynamic analysis of linear elastic structural systems. Element library includes 3-D truss, 3-D beam, isoparametric plane strain/stress, isoparametric 21 node, 3-D solid/thick shell, isoparametric thin shell, axisymmetric solid, 3-D pipe, boundary spring. Program time-history and spectral analysis capability. There are currently no graphics.
SAP 4	Ed Wilson, University of California Bill Hoyt, WESKA			600 Batch	X	3-D structural analysis program for linear systems. The program uses finite elements for static and dynamic problems with approximate mode shapes for the dynamic option.
SAPBEAM	H. W. Jones, WESKA	LMVD		G-635 Batch CARDIN	X	A modified general purpose structural analysis program (SAP4) that can automatically compute fixed end moments and shears on beam elements for in-span beam loads.
SAPPILE	H. W. Jones, WESKA	LMVD		G-635 Batch CARDIN	X	A modified general purpose structural analysis program (SAP4) with a three-dimensional pile element added. It is good for analysis of 3-D flexible cap pile foundations.
GENSAP	Agbabian Associates, Huntsville Division	ECPL	713-C8-7006F B	CDC 6400 Batch	X	"General Elastic and Non-linear Structural Analysis Program." This is a general purpose system for 3-D analysis of structural systems using the finite element method.
GENSAP	Agbabian-Jacobsen Associates, Los Angeles, California B. Haavisto, D. Reynolds, Sacramento District	Sacramento District	713X6L231A	BATCH/ CDC 7600 @ LBL	X	General elastic and nonlinear finite element structural analysis program. Element library includes 3-D truss, 3-D beam, plane strain, plane stress, axisymmetric solid, 3-D solid, thin plate/shell, and boundary spring. The program offers static and dynamic analysis, including time-history and spectral analyses. There are limited graphics in pre- and post-processors.
GENSAP	Adams, Portland District	NPD	713-K5-7006F A	IBM 360	X	General purpose 3-dimensional, static and dynamic analysis.
NASTRAN	Coell, Portland District	NPD	713-K5-00060 B	IBM 360	X	General purpose program.

3-D FRAME ANALYSIS PROGRAMS							
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER--OCE CATEGORY	COMPUTER/MODE	DOCUMENTED		DESCRIPTION
					YES	NO	
WASTRAN	Joe Hartman, St. Louis District MCAUTO						General purpose program.
TABS	University of California, Berkeley D. Reynolds, Sacramento District	Sacramento District	713-X6-L2-240	CDC 7600 @ LBL BATCH	X		Static and earthquake analyses of 3-D frame and shear wall buildings. Program gives linear structural analysis of frame and shear wall buildings subject to static and earthquake loadings. Beams and girders may be nonprismatic; bending and shearing deformation are included. Nonsymmetric, nonrectangular buildings having frames and shear walls in plan can be considered. Earthquake input is specified as an acceleration spectrum response.
NONSAP	University of California, Berkeley B. Haavisto, D. Reynolds, Sacramento District	Sacramento District	713X6L2	CDC 7600 @ LBL BATCH	X		Finite element program for static and dynamic analysis of nonlinear structural systems. Element library consists of 3-D truss, 3-8 node isoparametric plane strain/stress, 3-8 node isoparametric axisymmetric solid, 8-21 node isoparametric 3-D solid/thick shell. Available analysis procedures are: 1) Linear Elastic: assumes small displacements, infinitesimal strains, isotropic or orthotropic linear elastic material. 2) Materially Nonlinear: assumes small displacements, infinitesimal strains, nonlinear material stress-strain description. 3) Total Lagrangian Formulation: element may experience large displacements and strains, stress-strain relation is linear or nonlinear. 4) Updated Lagrangian Formulation: element may experience large displacements and strains; stress-strain relation is linear or nonlinear. Program designed for general incremental solution of nonlinear problems; linear analyses are possible also.
SAGS	Chicago District	INFONET					Static Analysis of General Structures including two- and three-dimensional frame structures.
SUPERB		INFONET					General purpose, structural analysis programs.
ECI STRUDL	Seattle District	Seattle District					General purpose, structural analysis and design programs.
ECI STRUDL	MCAUTO, New England Division Saint Louis District	WES Contract					General purpose, structural analysis and design programs.

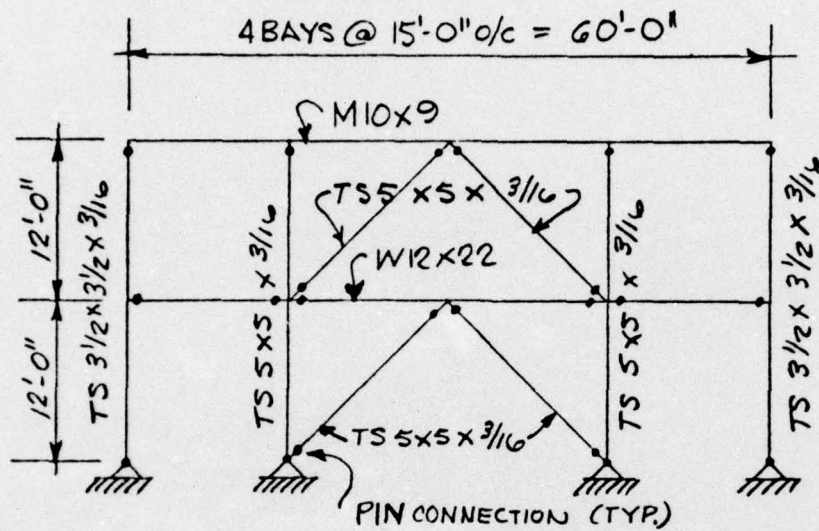
DESIGN PROGRAMS							
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER-- OCE CATEGORY	COMPUTER/ MODE	DOCUMENTED		DESCRIPTION
					YES	NO	
Analysis and Design of Flat Plates, Waffle Slabs and Continuous Frames	Portland Cement Association program Sacramento	SPK	713-58-L2-20C INFONET	UNV 1108 BATCH	X		1971 ACI-318 Bldg. Code analysis and design for flat plates, flat slabs (with drop panels), waffle slabs, and continuous concrete frames.
Analysis and Design, Flat Plates and Continuous Frames	Portland Cement Association program Ploudre, Seattle District	NPD	713-K5-G3280 A	IBM 360	X		
Composite Section Properties	Ploudre, Seattle District	NPD	713-K5-G3410 A	IBM 360	X		Computes section properties of any structural composite section.
AISC (Program in progress)	American Institute of Steel Construction	WESLIB		G-635TSS	X		Computer program for steel beam, girder, and floor framing design.
AISC (Program in progress)	American Institute of Steel Construction	WESLIB		G-635TSS	X		Computer program for steel column design.
GVSCAT 2 GVSCAT 3	G. V. Schwalbe, Thomas J. Mudd, St. Louis District			600TSS	X		Computes actual and allowable axial and bending stresses and the combined stress ratios for steel beam columns in accordance with 1969 AIS specifications.
PCABR	Portland Cement Association program	WESLIB		G-635TSS	X		Analysis and design of simple-span, precast, prestressed highway or railway bridges. The program uses 1968 AASHTO or AREA specifications.
PCAUC	Portland Cement Association program	WESLIB		G-635TSS	X		Ultimate strength design of reinforced concrete columns.
PCAUC	Ploudre, Portland Cement Association program	NPD	713-K5-G3300 A	IBM 360	X		Ultimate strength design of reinforced concrete columns.
Strength Design of Reinforced Concrete Column Sections	Portland Cement Association program, Sacramento	SPK	713-58-L2-20B	UNV 1108 BATCH	X		Capacity to design or investigate reinforced concrete compression members. AASHTO, 1973 Interior Spec. Sec. 5, Part 6, Load Factor Design, and ACI 318-71 Bldg. Code.
Concrete General Flexure Analysis	Ploudre, Seattle District	NPD	713-K5-G3010 A	IBM 360	X		
Reinforced Concrete Design for Flexure and Axial Load	Monroe, Portland District	NPD	713-K5-G0050	IBM 360	X		
DRCB	Robert Hall, WESKA			600TSS		X	Computes stresses for double reinforced concrete member by inputting strain of rebars.

POSTPROCESSOR PROGRAMS							
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER-- OCE CATEGORY	COMPUTER/ MODE	DOCUMENTED		DESCRIPTION
					YES	NO	
PCA-BM	Sefton Lucas, Memphis District	A1B400		600TSS		X	Post-processor for GFRAME computes resisting moment for concrete beam. The program checks shear at face of support, computes moment at fixed increments, and designs reinforcement for axial load plus bending.
POSMD	Galveston District	ECPL	713-G1-M3180	G-225 G-437	X		Links from program GFRAME (713-G1-A1040) and calculates shears, moments and axial forces at 1/10 point of each member for each load case. Call Wm. A. Price, PTS 601-636-3645 for information.
Beam Analysis One Span	Portland District	NPD	713-K5-G3110 A	IBM 360	X		

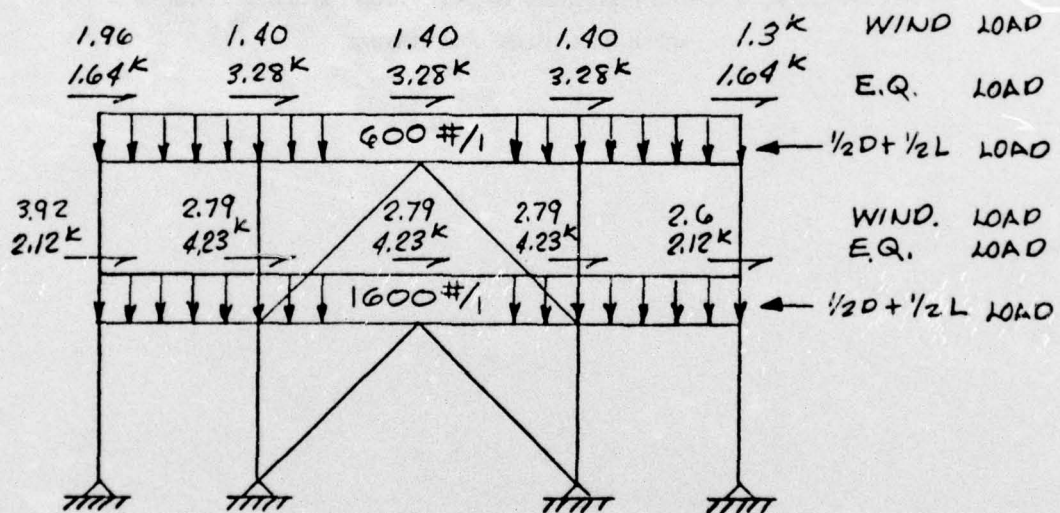
PRE-PROCESSOR PROGRAMS							
PROGRAM NAME	AUTHOR/CONTACT OFFICE	LIBRARY	PROGRAM NUMBER-- OCE CATEGORY	COMPUTER/ MODE	DOCUMENTED		DESCRIPTION
					YES	NO	
PREFEM	Fred Tracy, WESKA	WESLIB		G-635TSS Interactive Graphics	X		An interactive graphics program for automatically generating finite element grids and on-line data editing and numberings. It is a preprocessor finite element program.
POSTFEM	Fred Tracy, WESKA	WESLIB		G-635TSS Interactive Graphics	X		An interactive graphics program for post-processing finite element data. Programs can generate contour plots, vector plots, isometric and perspective plots.
3-D EDIT	Fred Tracy, WESKA	WESLIB		G-635 Batch	X		3-D edit program for the finite element program.
PRESAP	H. W. Jones, WESKA	LMVD		G-635TSS	X		An interactive time-sharing program to generate data for the General Purpose Structure Analysis Program (SAP).

Appendix B

Two-Story, Two-Dimensional Steel Frame Sample Problem
with District Solutions



FRAME ELEVATION



FRAME LOADS.

PROJECT 2-D FRAME SAMPLE PROBLEM

ITEM _____

COMPUTED BY _____

CHECKED BY _____

LOADING CASES

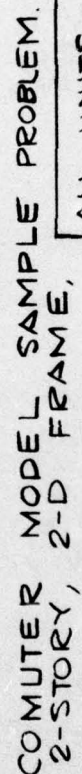
1	D.L.
2	L.L.
3	W.L.
4	E.Q.
5	D+L
6	D+L+W
7	D+ $\frac{1}{2}$ L+W
8	D+L+ $\frac{1}{2}$ W
9	.9D+W
10	D+L+E
11	D+ $\frac{1}{2}$ L+E
12	D+L+ $\frac{1}{2}$ E
13	.9D+E

→ RUN THIS LOAD CASE IF PROGRAM REQUIRES MORE THAN ONE RUN.

DISTRICT SOLUTIONS

<u>PROGRAM</u>	<u>DIV. OR DISTRICT CONTACT</u>
SAP IV	SACRAMENTO REYNOLDS
WILSON 2-D	SACRAMENTO REYNOLDS
SAGS	NORTH CENTRAL DIVISION SOUPOS
STRU DL	ST. LOUIS HARTMAN
NASTRAN	ST. LOUIS HARTMAN

REF. DRWG. NO. _____



6. DIAGONAL "K" BRACE (TRUSS ELEMENT)

1. COL. 1-2, 2-3, 10-11 & 11-12
2. COL. 4-5, 5-6, 14-15.
3. COL. 13-14, 14-15.

PROJECT 2-D FRAME SAMPLE PROBLEM
 ITEM SAP IV

SHEET NO. ___ OF ___ SHEETS

DATE ___, 19__

FILE _____

COMPUTED BY DWR CHECKED BY _____

REF. DRWG. NO. _____

ROOF LOADS. $L.L. = \frac{(30 \#/\text{sq}') (10')}{1000} = .3 \text{ K/1}$

D.L. ROOFING	6 #/sq'		
INSUL.	3		
ROOF DECKING	2		
O.W. J.	2		
M. & E.	15		
CEILING,	2		
		$\frac{(30 \#/\text{sq}') (10')}{1000} =$	$\frac{.3 \text{ K/1}}{1.6 \text{ K/1 D+L}}$

2ND FLOOR LOADS

$L.L. = \frac{(80 \#/\text{sq}') (10')}{1000} = .8 \text{ K/1}$

D.L. PARTITIONS	20 #/sq'		
4" CONC. DECK	40		
STL. DECK	2		
CEILING	2		
M. & E.	12		
O.W. J.	4		
		$\frac{(80 \#/\text{sq}') (10')}{1000} =$	$\frac{.8 \text{ K/1}}{1.6 \text{ K/1 D+L}}$

SIZE ROOF BEAMS.

$S_x = \frac{WL^2}{8f_b} = \frac{(.6)(15)^2(12)}{(8)(29)} = 8.44 \text{ IN}^3 \text{ REQ'D}$

TRY M10 x 9 $S_x = 7.76 \text{ IN}^3$

$A = 2.65 \text{ sq"}$
 $V_y = 1.108 \text{ sq"}$
 $V_x = 1.413 \text{ sq"}$
 $J = 0.033 \text{ IN}^4$
 $I_{yy} = 0.609 \text{ IN}^4$
 $I_{xx} = 38.80 \text{ IN}^4$

PROJECT 2-D FRAME SAMPLE PROBLEM.
ITEM SAP II

SHEET NO. ___ OF ___ SHEETS

DATE _____ 19 ____

FILE _____

COMPUTED BY DWR CHECKED BY _____

REF. DRWG. NO. _____

2ND FLOOR BEAM.

$$S_x = \frac{WL^2}{8f_b} = \frac{(1.6)(15)^2(12)}{(8)(24)} = 22.5 \text{ IN}^3 \text{ REQ'D}$$

TRY W12 x 22 BM. $S_x = 25.3 \text{ IN}^3$

$$\begin{aligned} A &= 6.47 \text{ IN}^2 \\ V_y &= 3.417 \text{ IN}^3 \\ V_x &= 2.69 \text{ IN}^3 \\ J &= 0.292 \text{ IN}^4 \\ I_{yy} &= 4.69 \text{ IN}^4 \\ I_{xx} &= 156.0 \text{ IN}^4 \end{aligned}$$

COLUMNS EXTERIOR COLS. GR 1 & 3.

		D.L.	L.L.
ROOF LOADS	$(7.5)(30) =$	2.25	2.25
2ND FLR	$(7.5)(8) =$	6.00	6.00
		<u>8.25</u>	<u>8.25</u>

BRACED FRAME

$$D.L. = 16.5 \text{ K}$$

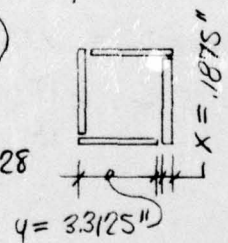
$$\frac{KL}{r} = (1.0)(12) = 12.0'$$

7S 3 1/2 x 3 1/2 x 3/16 $P = 31.0 \text{ K @ } L = 12' \quad F_y = 46 \text{ ksi}$

$$\begin{aligned} A &= 2.39 \text{ IN}^2 \\ V_y = V_x &= 1.195 \text{ IN}^3 \\ I_{xx} = I_{yy} &= 4.29 \text{ IN}^4 \end{aligned}$$

$$J = \sum \left(1 - .63 \frac{x}{y} \right) \left(\frac{x^3 y}{3} \right)$$

$$J = 4 \left[1 - (.63) \left(\frac{1.875}{3.3125} \right) \right] \left[\frac{(1.875)^3 (3.3125)}{3} \right] = 0.028$$



PROJECT 2-D FRAME SAMPLE PROGRAM
 ITEM SAP II

SHEET NO. ___ OF ___ SHEETS

DATE _____, 19__

FILE _____

COMPUTED BY DWR

CHECKED BY _____

REF. DRWG. NO. _____

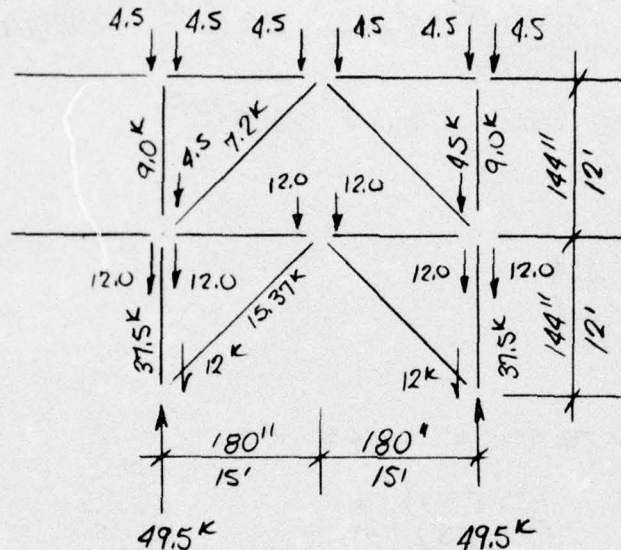
COLUMNS.

ROOF.

$$\text{ROOF } \frac{(15)(3)}{2} = 2.25 \text{ D.L.}$$

$$\frac{2.25}{2} = 1.125 \text{ LL}$$

$$1.125 + 1.125 = 2.25 \text{ DTL.}$$



2ND FLOOR

$$\frac{(15)(8)}{2} = 6.0 \text{ D.L.}$$

$$\frac{6.0}{2} = 3.0 \text{ L.L.}$$

$$3.0 + 3.0 = 6.0 \text{ DTL.}$$

TRY TS 5x5x 3/16

$$P = 67 \text{ K @ } L = 12'$$

$$P = 38 \text{ K @ } L = 19'$$

$$A = 3.49 \text{ in}^2$$

$$V_x = V_y = 1.745 \text{ in}^3$$

$$I_{xx} = I_{yy} = 13.2 \text{ in}^4$$

$$J = 4 \left[\left[1 - (0.63) \left(\frac{1.875}{4.8125} \right) \right] \left[\frac{(1.875)^3 (4.8125)}{3} \right] \right] = 0.041 \text{ in}^4$$

PROJECT 2-D FRAME SAMPLE PROBLEM.

ITEM SAP IV

SHEET NO. OF SHEETS

DATE 19

FILE

COMPUTED BY DWR.

CHECKED BY

REF. DRWG. NO.

WIND LOAD. $\begin{array}{r} .9 \text{ PRESSURE ON WINDWARD WALL} \\ .4 \text{ SUCTION ON LEEWARD WALL} \\ \hline 1.3 \end{array}$

31 #/ft'

$$\begin{array}{rcl} (.9 \times 31) & = & 21 \text{ #/ft'} \\ (.4 \times 31) & = & \frac{10}{31} \end{array}$$

ASSUME BUILDING IS 80' LONG.

TOTAL WIND LOAD. ROOF $(6' \times 80/2) (.031) = 7.44^k$
2ND FLR. $(12' \times 80/2) (.031) = 14.88^k$
 $\underline{22.32^k}$

WIND FORCE ON NODE ① $(10')(6')(0.021) = 1.26$
NODE ⑬ $(10' \times 6') (.010) = .60$

TOTAL WIND LOAD = 24.18^k

DIAPHRAGM SHEAR TO END WALL.

$$\begin{array}{rcl} \text{ROOF} & = & 7.44^k \\ \text{③} & - & 1.26 \\ \text{⑮} & - & .60 \\ \hline & = & 5.58^k / 720'' = .00775^k/'' \end{array}$$

TOTAL LOAD TO EACH NODE ON ROOF.

$$\text{③} = 1.26^k + (.00775)(90'') = 1.9575^k$$

$$\text{⑥, ⑨, ⑫, } (.00775)(180'') = (1.395)(3) = 4.1850^k$$

$$\text{⑮} = .6^k + (.00775)(90) = \frac{1.2957}{7.4382}^k$$

$$\begin{array}{rcl} \text{2ND FLOOR LOAD} & = & 14.88^k \\ \text{②} (10 \times 12 \times .021) & = & -2.52 \\ \text{⑭} (10 \times 12 \times .010) & = & -1.20 \\ \hline & = & 11.16^k / 720'' = .0155^k/'' \end{array}$$

PROJECT _____

ITEM _____

SHEET NO. _____ OF _____ SHEETS

DATE _____, 19____

FILE _____

COMPUTED BY _____

CHECKED BY _____

REF. DRWG. NO. _____

TOTAL LOAD TO EACH NODES ON 2ND FLR.

$$\textcircled{2} \quad 2.52 + (.0155)(90) = 3.915^k$$

$$\textcircled{5}, \textcircled{8}, \textcircled{11} \quad (.0155)(180) = (2.79)(3) = 8.37^k$$

$$\textcircled{14} \quad 1.2^k + (.0155)(90) = \underline{2.595^k}$$

$$14.88^k$$

LOAD CASE MULTIPLIERS.

WINDWARD COLUMN @ NODES $\textcircled{2}$ & $\textcircled{3}$

$$\textcircled{3} = 1.26^k = (M) \overset{A}{(2.39)} \overset{L}{(72)} \overset{\text{Wt. Density}}{(.000283)} \quad \underline{M = 25.874}$$

LEEWARD COLUMN. @ NODES $\textcircled{14}$ & $\textcircled{15}$

$$\textcircled{15} = 0.6^k = (M)(2.39)(72)(.000283) \quad \underline{M = 12.321}$$

ROOF DIAPHRAGM. NODE LOADS

$$\textcircled{6} = 1.395^k = (M)(2.65)(180)(.000283) \quad \underline{M = 10.335}$$

2ND FLOOR DIAPHRAGM NODE LOADS.

$$\textcircled{5} = 2.79^k = (M)(6.47)(180)(.000283) \quad \underline{M = 8.47}$$

PROJECT 2-D FRAME SAMPLE PROBLEM
ITEM SAP II

COMPUTED BY DWR.

CHECKED BY _____

SHEET NO. ____ OF ____ SHEETS

DATE _____, 19 ____

FILE _____

REF. DRWG. NO. _____

SEISMIC ZONE III

$$V = ZKCW$$

$$\begin{aligned} Z &= 1.0 \\ K &= 1.0 \\ C &= 0.1 \end{aligned}$$

$$V = (1.0)(1.0)(0.1)W = .1W$$

APPROX. INTERIOR FRAMES,

$$\text{RF. BMS } S_x = \frac{WL^2}{8f_b} = \frac{(1.2)(15)^2(12)}{(8)(24)} = 16.88 \text{ IN}^3$$

TRY W12X16.5 BM.

$$\text{2ND FLR. } S = \frac{(3.2)(15)^2(12)}{(8)(24)} = 45 \text{ IN}^3$$

TRY W16X31 BM.

COLUMNS. EXTERIOR. WALLS

$$\begin{aligned} \text{ROOF } (1.2)(7.5) &= 9^k & \text{TRY TS } 3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{4} \\ \text{2ND FLR. } (3.2)(7.5) &= \frac{24}{33^k} & P = 38^k @ L = 12' \\ & & Wt = 10.5 \#/\text{ft} \end{aligned}$$

INTERIOR COLUMN.

$$\begin{aligned} \text{RF } (1.2)(15) &= 18^k & \text{TS } 5 \times 5 \times \frac{3}{16} \text{ COL.} \\ \text{2ND FLR } (3.2)(15) &= \frac{48}{66^k} & Wt = 18 \#/\text{ft} \quad P = 64^k \end{aligned}$$

PROJECT 2-D FRAME SAMPLE PROBLEM
ITEM SAP IV

SHEET NO. ___ OF ___ SHEETS

DATE _____, 19__

FILE _____

REF. DRWG. NO. _____

COMPUTED BY DWR

CHECKED BY _____

SEISMIC
ROOF

$$\begin{aligned} \text{WT ROOF D.L. } (.03)(60)(80) &= 144^k \\ \text{WT. WALLS } (.01)(6')(280') &= 16.8^k \\ \text{WT. STRUCTURAL } (.01)(60') + (2)(6)(.008) & \\ \text{FRAME } + (2)(6)(.012) + (19)(.012) &= 1.07^k \\ \text{WT. INT. STRUCT. } [(.0165)(60) + (2)(6)(.01) & \\ \text{FRAME, } + (3)(6)(.012)] (3) &= 3.978^k \\ &= 166.918 \\ \text{RF. } &= 167^k \end{aligned}$$

2ND FLOOR

$$\begin{aligned} \text{2ND FLR. } (.08)(60)(80') &= 384^k \\ \text{WALLS } (.01)(12)(280') &= 33.6^k \\ \text{END } [(.022)(60) + (2)(12)(.008) & \\ \text{FRAME } + (2)(12)(.012) + (2)(19)(.012)] (2) &= 4.512^k \\ \text{INT. } [(.031)(60) + (2)(12)(.01) + & \\ \text{FRAME. } (3)(12)(.012)] (3) &= 7.596^k \\ &= 429.708^k \end{aligned}$$

$$2^{\text{ND}} \text{ FLR} = 430^k$$

$$V = (.1)(W) = (.1)(167 + 430) = 59.7^k$$

$$\text{EACH. END FRAME } V = 59.7/2 = 29.85^k$$

	h_x	W_x	$W_x h_x$	$\frac{W_x h_x}{\sum W_x h_x}$	F_x	V_x	
RF	24	167 ^k	4008	.437	13.11	13.11 ^k	$13.11/720 = .0182\%$
2ND	12	430 ^k	5160	.563	16.89	30.0 ^k	$16.89/720 = .0235\%$
	-	597 ^k	9168	1.000	30.0 ^k		

$$\begin{aligned} \text{RF. } \textcircled{3}, \textcircled{5} &= (90)(.0182) = 1.638^k \\ \textcircled{6}, \textcircled{9}, \textcircled{12} &= (180)(.0182) = 3.276^k \\ \text{MULTIPLIER} &= (24.27) \end{aligned}$$

$$\begin{aligned} 2^{\text{ND}} \text{ } \textcircled{2}, \textcircled{4} &= (90)(.0235) = 2.115^k \\ \text{FLR } \textcircled{5}, \textcircled{8}, \textcircled{11} &= (180)(.0235) = 4.23^k \\ \text{MULTIPLIER} &= (12.84) \end{aligned}$$

PROJECT: SAPIII SAMPLE PROBLEM. 2-STORY BLDG. 2-D FRAME DATE: 23 AUG 1968									
REQUESTED BY: REYNOLDS PREPARED BY: CHECKED BY: PAGE: 1 OF 4									
1	2	3	4	5	6	7	8	9	10
SAMPLE PROBLEM 2-STORY BLDG. 2-D FRAME									
21	1	0	0	1	0.00	0.00	0.00		
4	1	0	0	1	180.00	0.00	0.00		
10	1	0	0	1	540.00	0.00	0.00		
13	1	0	0	1	720.00	0.00	0.00		
2	1	0	0	1	0.00	144.00			
14	1	0	0	1	720.00	144.00		3	
3	1	0	0	1	0.00	288.00			
15	1	0	0	1	720.00	288.00		3	
7	1	1	1	1	-100.00	432.00			
16	1	1	1	1	0.00	-10.00			
20	1	1	1	1	720.00	-10.00			
21	1	1	1	1	0.00	730.00	0.00		
2	1	1	1	1	0.00				
1	30000.00	0.27	2.17-7	2.83-4					
1	2.39	1.19	1.19	0.028		4.29	4.29		
Blank Card									
1	1.00	25.874							
1	2	1	1						
2	2	1	1						
2	2	1	1						
1	30000.00	0.27	2.17-7	2.83-4					
1	3.49	1.75	1.75	0.041		13.20	13.20		
Blank Card									
Blank Card									
1	1.00								
1	10	1	1						
2	10	1	1						

PROGRAM SAP II SAMPLE PROBLEM 2-STORY BLDG 2-D FRAME DATE 23 AUG 75									
REQUESTED BY REYNOLDS									
PREPARED BY									
CHECKED BY									
PAGE 2 of 4									
1	2	3	4	5	6	7	8	9	10
1	5	7	1	1	1	1	1	1	1
2	11	7	1	1	1	1	1	1	1
3	5	7	1	1	1	1	1	1	1
4	11	7	1	1	1	1	1	1	1
5	12	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1
7	30000.00	0.27	2.17-7	2.83-4	4.29	4.29	4.29	4.29	4.29
8	2.39	1.19	1.19	0.028					
Blank card									
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0039 43 OUTPUT . 27 AUG 75 . 14.03 0039 43

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0039 03 CUNT . 27 AUG 75 . 14.00 0034 43

RETURN TO
CUBA
SACTO
DE VUELTA
AUB

14.01.531	SAPCE05	1	75/08/27	7600	RKYISA	3	SAP4	NORM	803943	REYNOLDS
14.01.531	INPUT	6600B	14.00.30	27	AUG 75	VIA	COKE			
14.01.531	SAP4,P3,I30,	CM170000	803943,	REYNOLDS						
14.01.531	FETCHMT,	SSAP,	26143,	IF.						
14.01.54	SSAP		DISK 1							
14.01.57	SSAP		65905	WORDS	COPIED	FROM	CACHE.			
14.01.57	REMINO,SSAP.									
14.01.57	SSAP,LC=7777									
14.01.58	FLS=170K	FLL=0001K	LCM	BUFFERS=0034K	TOTAL	LCM=0225K				
14.01.58	OUTPUT	DISK 1								
14.01.58	TAPE8	DISK 1								
14.01.58	TAPE1	DISK 1								
14.01.58	TAPE2	DISK 1								
14.02.00	FLS=170K	FLL=0005K	LCM	BUFFERS=0234K	TOTAL	LCM=0431K				
14.02.00	TAPE3	DISK 1								
14.02.00	TAPE4	DISK 1								
14.02.00	TAPE9	DISK 1								
14.02.02	STOP									
14.02.02	DISK USED	480	SECTORS							
14.02.02	LCM BLD.	27								
14.02.02	ITO	4.617								
14.02.02	CPU TIME	0.582	SECONDS.							
14.02.02	STAGING	0	CUS.							
14.02.02	75/08/27.	21	CUS.							
14.02.02.		2,170	EST.							
14.03.05	SAPCE05.	OUTPUT	QUEUED	PR	152					

SAMPLE PROBLEM 2 STORY BLDG 2-D FRAME

C O N T R O L I N F O R M A T I O N

NUMBER OF NODAL POINTS = 21

NUMBER OF ELEMENT TYPES = 7

NUMBER OF LOAD CASES = 13

NUMBER OF FREQUENCIES = -0

ANALYSIS CODE (NDYN) = -0

EQ,0, STATIC

EQ,1, MODAL EXTRACTION

EQ,2, FORCED RESPONSE

EQ,3, RESPONSE SPECTRUM

EQ,4, DIRECT INTEGRATION

SOLUTION MODE (MODEX) = -0

EQ,0, EXECUTION

EQ,1, DATA CHECK

NUMBER OF SUBSPACE

ITERATION VECTORS (NAD) = -0

EQUATIONS PER BLOCK = -0

TAPE10 SAVE FLAG (N10SV) = -0

LOCAL POINT COORDINATES

64

GENERATED NODAL DATA

NODE NUMBER	BOUNDARY CONDITION			CODES			NODAL POINT COORDINATES			
	X	Y	Z	XX	YY	ZZ	X	Y	Z	T
1	1	0	0	0	1	1	0.000	0.000	0.000	-0.000
2	1	0	0	0	1	1	0.000	0.000	144.000	-0.000
3	1	0	0	0	1	1	0.000	0.000	288.000	-0.000
4	1	0	0	0	1	1	0.000	180.000	0.000	-0.000
5	1	0	0	0	1	1	0.000	180.000	144.000	0.000
6	1	0	0	0	1	1	0.000	180.000	288.000	0.000
7	1	1	1	1	1	1	0.000	-100.000	432.000	-0.000
8	1	0	0	0	1	1	0.000	360.000	144.000	0.000
9	1	0	0	0	1	1	0.000	360.000	288.000	0.000
10	1	0	0	0	1	1	0.000	540.000	0.000	-0.000
11	1	0	0	0	1	1	0.000	540.000	144.000	0.000
12	1	0	0	0	1	1	0.000	540.000	288.000	0.000
13	1	0	0	0	1	1	0.000	720.000	0.000	-0.000
14	1	0	0	0	1	1	0.000	720.000	144.000	-0.000
15	1	0	0	0	1	1	0.000	720.000	288.000	-0.000
16	1	1	1	1	1	1	0.000	0.000	-10.000	-0.000
17	1	1	1	1	1	1	0.000	180.000	-10.000	0.000
18	1	1	1	1	1	1	0.000	360.000	-10.000	0.000
19	1	1	1	1	1	1	0.000	540.000	-10.000	0.000
20	1	1	1	1	1	1	0.000	720.000	-10.000	-0.000
21	1	1	1	1	1	1	0.000	720.000	0.000	-0.000

EQUATION NUMBERS

N	X	Y	Z	XX	YY	ZZ
1	0	1	2	3	0	0
2	0	4	5	6	0	0
3	0	7	8	9	0	0
4	0	10	11	12	0	0
5	0	13	14	15	0	0
6	0	16	17	18	0	0
7	0	0	0	0	0	0
8	0	19	20	21	0	0
9	0	22	23	24	0	0
10	0	25	26	27	0	0
11	0	28	29	30	0	0
12	0	31	32	33	0	0
13	0	34	35	36	0	0
14	0	37	38	39	0	0
15	0	40	41	42	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0

3 / D B E A M E L E M E N T S

GP - #1

COLUMNS

NUMBER OF BEAMS = 2
 NUMBER OF GEOMETRIC PROPERTY SETS = 1
 NUMBER OF FIXED END FORCE SETS = 0
 NUMBER OF MATERIALS = 1

MATERIAL PROPERTIES

MATERIAL NUMBER	YOUNG'S MODULUS	POISSON'S RATIO	MASS DENSITY	WEIGHT DENSITY
1	3.0000E+04	.2700	2.1700E-07	2.6300E-04

BEAM GEOMETRIC PROPERTIES

SECTION NUMBER	AXIAL AREA A(1)	SHEAR AREA A(2)	SHEAR AREA A(3)	TORSION J(1)	INERTIA I(2)	INERTIA I(3)
1	2.3900E+00	1.1900E+00	1.1900E+00	2.8000E-02	4.2900E+00	4.2900E+00

ELEMENT LOAD MULTIPLIERS

	A	B	C	D
X=DIR	-0.	-0.	-0.	-0.
Y=DIR	-0.	-0.	2.587400E+01	-0.
Z=DIR	-1.000000E+00	-0.	-0.	-0.

3/D BEAM ELEMENT DATA

BEAM NUMBER	NODE -I	NODE -J	NODE -K	MATERIAL NUMBER	SECTION NUMBER	ELEMENT A	ELEMENT B	ELEMENT C	ELEMENT D	END CODES -I -J -K -L
1	1	2	7	1	1	-0	-0	-0	-0	1 -0
2	2	3	7	1	1	-0	-0	-0	-0	1 -0

3 / 0 B E A M E L E M E N T S

GP-2

COLUMNS

NUMBER OF BEAMS 4
 NUMBER OF GEOMETRIC PROPERTY SETS 1
 NUMBER OF FIXED END FORCE SETS 0
 NUMBER OF MATERIALS 1

MATERIAL PROPERTIES

MATERIAL NUMBER	YOUNG'S MODULUS	POISSON'S RATIO	MASS DENSITY	WEIGHT DENSITY
1	3.0000E+04	.2700	2.1700E-07	2.8300E-04

BEAM GEOMETRIC PROPERTIES

SECTION NUMBER	AXIAL AREA A(1)	SHEAR AREA A(2)	SHEAR AREA A(3)	TORSION J(1)	INERTIA I(2)	INERTIA I(3)
1	3.4900E+00	1.7500E+00	1.7500E+00	4.1000E-02	1.3200E+01	1.3200E+01

ELEMENT LOAD MULTIPLIERS

	A	B	C	D
X=DIR	-0.	-0.	-0.	-0.
Y=DIR	-0.	-0.	-0.	-0.
Z=DIR	-1.000000E+00	-0.	-0.	-0.

3/D BEAM ELEMENT DATA

BEAM NUMBER	NODE -I	NODE -J	NODE -K	MATERIAL NUMBER	SECTION NUMBER	ELEMENT A	ELEMENT B	ELEMENT C	ELEMENT D	END CODES -I -J -K
1	4	5	7	1	1	-0	-0	-0	-0	1 -0 -0
2	10	11	7	1	1	-0	-0	-0	-0	1 -0 -0
3	5	6	7	1	1	-0	-0	-0	-0	-0 1 -0
4	11	12	7	1	1	-0	-0	-0	-0	-0 1 -0

3 / 0 B E A M E L E M E N T S

GROUP - 3

COLUMNS

NUMBER OF BEAMS 2
 NUMBER OF GEOMETRIC PROPERTY SETS 1
 NUMBER OF FIXED END FORCE SETS 0
 NUMBER OF MATERIALS 1

MATERIAL PROPERTIES

MATERIAL NUMBER	YOUNG'S MODULUS	POISSON'S RATIO	MASS DENSITY	WEIGHT DENSITY
1	3.0000E+04	.2700	2.1700E-07	2.6300E-04

BEAM GEOMETRIC PROPERTIES

SECTION NUMBER	AXIAL AREA A(1)	SHEAR AREA A(2)	SHEAR AREA A(3)	TORSION J(1)	INERTIA I(2)	INERTIA I(3)
1	2.3900E+00	1.1900E+00	1.1900E+00	2.8000E-02	4.2900E+00	4.2900E+00

ELEMENT LOAD MULTIPLIERS

A	B	C
-0.	-0.	0
-0.	1.232100E+01	-0.
-1.000000E+00	-0.	-0.

3/0 BEAM ELEMENT DATA

BEAM NUMBER	NODE -I	NODE -J	NODE -K	MATERIAL NUMBER	SECTION NUMBER	ELEMENT A	ELEMENT B	ELEMENT C	END LOADS D	END CODES -I	-J	-K
1	13	14	7	1	1	-0	-0	-0	-0	1	-0	-0
2	14	15	7	1	1	-0	-0	-0	-0	1	-0	-0

3 / 0 B E A M E L E M E N T S

GP-4 ROOF BEAMS

NUMBER OF BEAMS 4
 NUMBER OF GEOMETRIC PROPERTY SETS 1
 NUMBER OF FIXED END FORCE SETS 2
 NUMBER OF MATERIALS 1

MATERIAL PROPERTIES

MATERIAL NUMBER	YOUNG'S MODULUS	POISSON'S RATIO	MASS DENSITY	WEIGHT DENSITY
1	3.0000E+04	.2700	2.1700E-07	2.8300E-04

BEAM GEOMETRIC PROPERTIES

SECTION NUMBER	AXIAL AREA A(1)	SHEAR AREA A(2)	SHEAR AREA A(3)	TORSION J(1)	INERTIA I(2)	INERTIA I(3)
1	2.6500E+00	1.1100E+00	1.4130E+00	3.3000E-02	6.0900E-01	3.8800E+01

ELEMENT LOAD MULTIPLIERS

	A	B	C	D
X-DIR -0.	-0.	-0.	-0.	-0.
Y-DIR -0.	-0.	1.033500E+01	2.427000E+01	-0.
Z-DIR -0.	-0.	-0.	-0.	-0.

FIXED END FORCES IN LOCAL COORDINATES

TYPE	NODE	FORCE X	FORCE Y	FORCE Z	MOMENT X	MOMENT Y	MOMENT Z
1	I	0.000	2.250	0.000	0.000	0.000	67.500
	J	0.000	2.250	0.000	0.000	0.000	-67.500
2	I	0.000	2.250	0.000	0.000	0.000	67.500
	J	0.000	2.250	0.000	0.000	0.000	-67.500

3/D BEAM ELEMENT DATA

BEAM NUMBER	NODE -I	NODE -J	NODE -K	MATERIAL NUMBER	SECTION NUMBER	ELEMENT A	ELEMENT B	END LOADS C	END CODES -I	-J	-K
1	3	6	7	1	1	1	2	-0	1	-0	-0
2	6	9	7	1	1	1	2	-0	-0	-0	-0
3	9	12	7	1	1	1	2	-0	-0	-0	-0
4	12	15	7	1	1	1	2	-0	-0	-0	1

3 / 0 B E A M E L E M E N T S

NUMBER OF BEAMS = 4
 NUMBER OF GEOMETRIC PROPERTY SETS = 1
 NUMBER OF FIXED END FORCE SETS = 2
 NUMBER OF MATERIALS = 1

GROUP 5
 2ND FLOOR BMS

MATERIAL PROPERTIES

MATERIAL NUMBER	YOUNG'S MODULUS	POISSON'S RATIO	MASS DENSITY	WEIGHT DENSITY
1	3.0000E+04	.2700	2.1700E+07	2.6300E+04

BEAM GEOMETRIC PROPERTIES

SECTION NUMBER	AXIAL AREA A(1)	SHEAR AREA A(2)	SHEAR AREA A(3)	TORSION J(1)	INERTIA I(2)	INERTIA I(3)
1	6.4700E+00	3.4200E+00	2.0900E+00	2.9200E+01	4.6400E+00	1.5500E+02

ELEMENT LOAD MULTIPLIERS

	A	B	C	D
X=DIR	-0.	-0.	-0.	0
Y=DIR	-0.	-0.	8.470000E+00	1.284000E+01
Z=DIR	-0.	-0.	-0.	-0.

FIXED END FORCES IN LOCAL COORDINATES

TYPE	NODE	FORCE X	FORCE Y	FORCE Z	MOMENT X	MOMENT Y	MOMENT Z
1	I	0.000	0.000	0.000	0.000	0.000	180.000
	J	0.000	0.000	0.000	0.000	0.000	-180.000
2	I	0.000	0.000	0.000	0.000	0.000	180.000
	J	0.000	0.000	0.000	0.000	0.000	-180.000

3/D BEAM ELEMENT DATA

BEAM NUMBER	NODE -I	NODE -J	NODE -K	MATERIAL NUMBER	SECTION NUMBER	ELEMENT A	END B	LOADS C	END D	COUES -J
1	2	5	7	1	1	1	2	-0	-0	1
2	5	6	7	1	1	1	2	-0	-0	1
3	6	11	7	1	1	1	2	-0	-0	1
4	11	14	7	1	1	1	2	-0	-0	1

GROUP - 6
DIAGONAL "K" BRACES.

NUMBER OF TRUSS MEMBERS 4
NUMBER OF DIFF. MEMBERS 1

TYPE 1 E 3.0000000E+04 0. ALPHA 7.3400000E+07 DEN 3.4900000E+00 AREA 2.8300000E+04 WT

ELEMENT LOAD MULTIPLIERS

	A	B	C	D
X=DIR	=0.	=0.	=0.	=0.
Y=DIR	=0.	=0.	=0.	=0.
Z=DIR	=1.000000E+00	=0.	=0.	=0.
TEMP	=0.	=0.	=0.	=0.

N	I	J	TYPE	TEMP	BAND
1	4	9	1	=0.00	11
2	5	9	1	=0.00	11
3	6	10	1	=0.00	8
4	9	11	1	=0.00	6

BOUNDARY ELEMENTS

GROUP 7

ELEMENT TYPE 7
NUMBER OF ELEMENTS 6

ELEMENT LOAD CASE MULTIPLIERS

CASE (A)	CASE (B)	CASE (C)	CASE (D)
1.0000	1.0000	1.0000	1.0000

ELEMENT NUMBER	NODE (N)	NODES DEFINING CONSTRAINT (N1)	(N2)	(N3)	CONNECTION (N4)	CODE (N5)	CODE (N6)	GENERATION CODE (N7)	SPECIFIED DISPLACEMENT	SPECIFIED ROTATION	SPRING RATE
1	1	16	-0	-0	-0	1	-0	-0	-0	-0	1.0000E+10
2	1	21	-0	-0	-0	1	-0	-0	-0	-0	1.0000E+10
3	4	17	-0	-0	-0	1	-0	-0	-0	-0	1.0000E+10
4	4	21	-0	-0	-0	1	-0	-0	-0	-0	1.0000E+10
5	10	19	-0	-0	-0	1	-0	-0	-0	-0	1.0000E+10
6	10	21	-0	-0	-0	1	-0	-0	-0	-0	1.0000E+10
7	13	20	-0	-0	-0	1	-0	-0	-0	-0	1.0000E+10
8	13	21	-0	-0	-0	1	-0	-0	-0	-0	1.0000E+10

EQUATION PARAMETERS

TOTAL NUMBER OF EQUATIONS	=	42
BANDWIDTH	=	12
NUMBER OF EQUATIONS IN A BLOCK	=	40
NUMBER OF BLOCKS	=	2

NODAL LOADS (STATIC) OR MASSES (DYNAMIC)							
NODE NUMBER	LOAD CASE	X-AXIS FORCE	Y-AXIS FORCE	Z-AXIS FORCE	X-AXIS MOMENT	Y-AXIS MOMENT	Z-AXIS MOMENT
STRUCTURE							
LOAD CASE							
		ELEMENT		LOAD		MULTIPLIERS	
		A	M	C	D		
1	1.000	-0.000	-0.000	-0.000	-0.000		
2	-0.000	1.000	-0.000	-0.000	-0.000		
3	-0.000	-0.000	1.000	-0.000	-0.000		
4	-0.000	-0.000	-0.000	1.000	-0.000		
5	1.000	1.000	-0.000	-0.000	-0.000		
6	1.000	1.000	1.000	-0.000	-0.000		
7	1.000	1.500	1.500	-0.000	-0.000		
8	1.000	1.000	1.500	-0.000	-0.000		
9	.500	-0.000	1.000	-0.000	-0.000		
10	1.000	1.000	-0.000	1.000	-0.000		
11	1.000	.500	-0.000	1.000	-0.000		
12	1.000	1.000	-0.000	1.500	-0.000		
13	.500	-0.000	-0.000	-0.000	-0.000		

NODE DISPLACEMENTS/ROTATIONS

NODE NUMBER	LOAD CASE	X=	Y=	Z=	X=	Y=	Z=
		TRANSLATION	TRANSLATION	TRANSLATION	ROTATION	ROTATION	ROTATION
21	1	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.
	4	0.	0.	0.	0.	0.	0.
	5	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.
	8	0.	0.	0.	0.	0.	0.
	9	0.	0.	0.	0.	0.	0.
	10	0.	0.	0.	0.	0.	0.
	11	0.	0.	0.	0.	0.	0.
	12	0.	0.	0.	0.	0.	0.
	13	0.	0.	0.	0.	0.	0.
20	1	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.
	4	0.	0.	0.	0.	0.	0.
	5	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.
	8	0.	0.	0.	0.	0.	0.
	9	0.	0.	0.	0.	0.	0.
	10	0.	0.	0.	0.	0.	0.
	11	0.	0.	0.	0.	0.	0.
	12	0.	0.	0.	0.	0.	0.
	13	0.	0.	0.	0.	0.	0.
19	1	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.
	4	0.	0.	0.	0.	0.	0.
	5	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.
	8	0.	0.	0.	0.	0.	0.
	9	0.	0.	0.	0.	0.	0.
	10	0.	0.	0.	0.	0.	0.
	11	0.	0.	0.	0.	0.	0.
	12	0.	0.	0.	0.	0.	0.
	13	0.	0.	0.	0.	0.	0.
18	1	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.
	4	0.	0.	0.	0.	0.	0.
	5	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.
	8	0.	0.	0.	0.	0.	0.
	9	0.	0.	0.	0.	0.	0.
	10	0.	0.	0.	0.	0.	0.
	11	0.	0.	0.	0.	0.	0.
	12	0.	0.	0.	0.	0.	0.
	13	0.	0.	0.	0.	0.	0.
17	1	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.
	4	0.	0.	0.	0.	0.	0.
	5	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.
	8	0.	0.	0.	0.	0.	0.
	9	0.	0.	0.	0.	0.	0.
	10	0.	0.	0.	0.	0.	0.
	11	0.	0.	0.	0.	0.	0.
	12	0.	0.	0.	0.	0.	0.
	13	0.	0.	0.	0.	0.	0.

10	1	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.
	4	0.	0.	0.	0.	0.	0.
	5	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.
	8	0.	0.	0.	0.	0.	0.
	9	0.	0.	0.	0.	0.	0.
	10	0.	0.	0.	0.	0.	0.
	11	0.	0.	0.	0.	0.	0.
	12	0.	0.	0.	0.	0.	0.
	13	0.	0.	0.	0.	0.	0.
15	1	0.	3.78320E-06	-1.95500E-02	5.11010E-34	0.	0.
	2	0.	3.58923E-06	-1.91657E-02	5.10201E-34	0.	0.
	3	0.	7.51218E-02	-1.12500E-05	3.55447E-36	0.	0.
	4	0.	1.10454E-01	-1.71345E-05	-3.07547E-36	0.	0.
	5	0.	7.37244E-06	-3.87217E-02	1.02122E-33	0.	0.
	6	0.	7.51292E-02	-3.87330E-02	1.02478E-33	0.	0.
	7	0.	7.51274E-02	-2.91501E-02	7.69678E-34	0.	0.
	8	0.	3.75663E-02	-3.87217E-02	1.02300E-33	0.	0.
	9	0.	7.51252E-02	-1.76116E-02	4.63470E-34	0.	0.
	10	0.	1.10461E-01	-3.87386E-02	1.01619E-33	0.	0.
	11	0.	1.10454E-01	-2.91500E-02	7.63042E-34	0.	0.
	12	0.	9.52342E-02	-3.87303E-02	1.01968E-33	0.	0.
	13	0.	1.10457E-01	-1.76175E-02	4.56836E-34	0.	0.
14	1	0.	2.55225E-03	-1.59009E-02	-1.31363E-08	0.	0.
	2	0.	2.42136E-03	-1.56080E-02	-1.24626E-08	0.	0.
	3	0.	5.11280E-02	-5.62800E-06	-2.60840E-04	0.	0.
	4	0.	6.81104E-02	-4.56975E-06	-3.03514E-04	0.	0.
	5	0.	4.97361E-03	-1.5069E-02	-2.55464E-08	0.	0.
	6	0.	5.51016E-02	-1.13145E-02	-2.60665E-04	0.	0.
	7	0.	5.44909E-02	-2.37105E-02	-2.60594E-04	0.	0.
	8	0.	3.04376E-02	-3.15117E-02	-1.30445E-04	0.	0.
	9	0.	5.34250E-02	-1.43164E-02	-2.60651E-04	0.	0.
	10	0.	7.30640E-02	-1.15174E-02	-3.83545E-04	0.	0.
	11	0.	7.16733E-02	-2.37135E-02	-3.83539E-04	0.	0.
	12	0.	3.90288E-02	-3.15132E-02	-1.91785E-04	0.	0.
	13	0.	7.04074E-02	-1.43144E-02	-3.63331E-04	0.	0.
13	1	0.	3.29335E-14	-7.46602E-10	7.46622E-47	0.	0.
	2	0.	3.12444E-14	-7.77147E-10	7.10419E-47	0.	0.
	3	0.	6.01768E-11	-2.80226E-13	1.36826E-43	0.	0.
	4	0.	1.66370E-13	-4.26702E-13	3.76282E-46	0.	0.
	5	0.	6.41761E-14	-1.57375E-09	1.45924E-40	0.	0.
	6	0.	6.02410E-11	-1.57403E-09	1.36472E-43	0.	0.
	7	0.	6.02253E-11	-1.16546E-09	1.36437E-43	0.	0.
	8	0.	3.01520E-11	-1.57304E-09	6.85541E-44	0.	0.
	9	0.	6.02064E-11	-7.17222E-10	1.36844E-43	0.	0.
	10	0.	2.30548E-13	-1.57418E-09	5.24208E-46	0.	0.
	11	0.	2.14926E-13	-1.16560E-09	4.86605E-46	0.	0.
	12	0.	1.87363E-13	-1.57346E-09	3.35065E-46	0.	0.
	13	0.	1.96010E-13	-7.17368E-10	4.45676E-46	0.	0.
12	1	0.	3.03754E-06	-3.22340E-02	-6.69667E-04	0.	0.
	2	0.	2.88161E-06	-3.15276E-02	-6.75420E-04	0.	0.
	3	0.	7.21794E-02	-4.08523E-03	-3.58105E-06	0.	0.
	4	0.	1.06741E-01	-7.14352E-03	-4.76047E-06	0.	0.
	5	0.	5.41940E-06	-6.37614E-02	-1.34374E-03	0.	0.
	6	0.	7.21850E-02	-6.78671E-02	-1.34737E-03	0.	0.
	7	0.	7.21844E-02	-5.20832E-02	-1.01044E-03	0.	0.
	8	0.	3.80959E-02	-6.58045E-02	-1.34550E-03	0.	0.
	9	0.	7.21826E-02	-3.30954E-02	-6.06401E-04	0.	0.
	10	0.	1.06747E-01	-7.09554E-02	-1.34384E-03	0.	0.
	11	0.	1.06745E-01	-5.51915E-02	-1.00687E-03	0.	0.
	12	0.	5.33764E-02	-6.73566E-02	-1.34381E-03	0.	0.
	13	0.	1.06744E-01	-3.47042E-02	-6.02420E-04	0.	0.

11	1	0.	2.55266E-03	-2.50644E-02	-1.05439E-04	0.	0.
	2	0.	2.42194E-03	-2.44624E-02	-1.00031E-04	0.	0.
	3	0.	4.87240E-02	-4.04381E-03	-2.50625E-04	0.	0.
	4	0.	6.61513E-02	-7.20529E-03	-3.70621E-04	0.	0.
	5	0.	4.97480E-03	-4.95318E-02	-2.05470E-04	0.	0.
	6	0.	5.30488E-02	-5.36256E-02	-2.50645E-04	0.	0.
	7	0.	5.24478E-02	-4.13944E-02	-2.50641E-04	0.	0.
	8	0.	2.93368E-02	-5.15787E-02	-1.25333E-04	0.	0.
	9	0.	5.10216E-02	-2.66563E-02	-2.50634E-04	0.	0.
	10	0.	7.11261E-02	-5.67370E-02	-3.70649E-04	0.	0.
	11	0.	6.49151E-02	-4.45058E-02	-3.70644E-04	0.	0.
	12	0.	3.80504E-02	-5.31344E-02	-1.85335E-04	0.	0.
	13	0.	6.84489E-02	-2.97677E-02	-3.70635E-04	0.	0.
10	1	0.	9.44612E-10	-2.59666E-09	8.54120E-42	0.	0.
	2	0.	9.30386E-10	-2.52265E-09	8.46183E-42	0.	0.
	3	0.	1.11015E-09	-1.19018E-09	1.01514E-41	0.	0.
	4	0.	1.50145E-09	-1.72463E-09	1.36656E-41	0.	0.
	5	0.	1.87500E-09	-3.11971E-09	1.70530E-41	0.	0.
	6	0.	2.97115E-09	-6.30704E-09	2.72046E-41	0.	0.
	7	0.	2.52546E-09	-5.04640E-09	2.24735E-41	0.	0.
	8	0.	2.43302E-09	-5.71600E-09	2.21287E-41	0.	0.
	9	0.	1.96630E-09	-3.52735E-09	1.76834E-41	0.	0.
	10	0.	3.37645E-09	-6.84434E-09	3.07006E-41	0.	0.
	11	0.	2.91125E-09	-5.58242E-09	2.64717E-41	0.	0.
	12	0.	2.62572E-09	-5.96203E-09	2.36606E-41	0.	0.
	13	0.	2.35160E-09	-4.06180E-09	2.13877E-41	0.	0.
9	1	0.	-4.94600E-16	-4.06971E-02	4.72575E-18	0.	0.
	2	0.	-4.60422E-16	-3.92887E-02	9.81367E-20	0.	0.
	3	0.	6.64674E-02	7.56076E-04	-3.37724E-05	0.	0.
	4	0.	9.55988E-02	-3.85159E-16	-5.94340E-05	0.	0.
	5	0.	-9.99201E-16	-7.44858E-02	7.24325E-18	0.	0.
	6	0.	6.60679E-02	-7.42278E-02	-3.37729E-05	0.	0.
	7	0.	6.60679E-02	-5.95834E-02	-3.37724E-05	0.	0.
	8	0.	3.30339E-02	-7.90088E-02	-1.86864E-05	0.	0.
	9	0.	6.60679E-02	-3.58694E-02	-3.37729E-05	0.	0.
	10	0.	9.55988E-02	-7.44858E-02	-5.94340E-05	0.	0.
	11	0.	9.55988E-02	-6.03415E-02	-5.94340E-05	0.	0.
	12	0.	4.77444E-02	-7.44858E-02	-2.47170E-05	0.	0.
	13	0.	9.55988E-02	-3.00274E-02	-5.94340E-05	0.	0.
8	1	0.	-9.25367E-17	-4.26294E-02	2.85413E-18	0.	0.
	2	0.	-4.19586E-17	-4.19870E-02	2.56711E-18	0.	0.
	3	0.	4.02424E-02	6.66301E-04	-2.27463E-05	0.	0.
	4	0.	5.41944E-02	7.74524E-16	-4.06242E-05	0.	0.
	5	0.	-2.54558E-16	-6.46109E-02	5.70807E-18	0.	0.
	6	0.	4.02424E-02	-6.46109E-02	-2.27463E-05	0.	0.
	7	0.	4.02424E-02	-6.36231E-02	-2.27463E-05	0.	0.
	8	0.	2.01414E-02	-6.46109E-02	-1.13731E-05	0.	0.
	9	0.	4.02424E-02	-3.83604E-02	-2.27463E-05	0.	0.
	10	0.	5.41944E-02	-6.46109E-02	-4.06242E-05	0.	0.
	11	0.	5.41944E-02	-6.36231E-02	-4.06242E-05	0.	0.
	12	0.	2.70472E-02	-6.46109E-02	-2.00146E-05	0.	0.
	13	0.	5.41944E-02	-3.83604E-02	-4.06242E-05	0.	0.
7	1	0.	0.	0.	0.	0.	0.
	2	0.	0.	0.	0.	0.	0.
	3	0.	0.	0.	0.	0.	0.
	4	0.	0.	0.	0.	0.	0.
	5	0.	0.	0.	0.	0.	0.
	6	0.	0.	0.	0.	0.	0.
	7	0.	0.	0.	0.	0.	0.
	8	0.	0.	0.	0.	0.	0.
	9	0.	0.	0.	0.	0.	0.
	10	0.	0.	0.	0.	0.	0.
	11	0.	0.	0.	0.	0.	0.
	12	0.	0.	0.	0.	0.	0.
	13	0.	0.	0.	0.	0.	0.

6	1	0.	-3.03759E-06	-3.22340E-02	6.69867E-04	0.	0.
	2	0.	-2.88181E-06	-3.15278E-02	6.73920E-04	0.	0.
	3	0.	7.36750E-02	4.09008E-03	3.52694E-08	0.	0.
	4	0.	1.06741E-01	7.14352E-03	-4.76097E-08	0.	0.
	5	0.	-5.91940E-06	-6.37619E-02	1.34379E-03	0.	0.
	6	0.	7.36691E-02	-5.46718E-02	1.34731E-03	0.	0.
	7	0.	7.36705E-02	-4.39079E-02	1.01035E-03	0.	0.
	8	0.	3.66316E-02	-6.17168E-02	1.34555E-03	0.	0.
	9	0.	7.36722E-02	-2.49206E-02	6.06407E-04	0.	0.
	10	0.	1.06735E-01	-5.85654E-02	1.34374E-03	0.	0.
	11	0.	1.06736E-01	-4.08044E-02	1.00673E-03	0.	0.
	12	0.	5.33545E-02	-6.01651E-02	1.34375E-03	0.	0.
	13	0.	1.06736E-01	-2.18171E-02	6.02833E-04	0.	0.
5	1	0.	-2.55286E-03	-2.50694E-02	1.05439E-08	0.	0.
	2	0.	-2.42194E-03	-2.44624E-02	1.00031E-08	0.	0.
	3	0.	4.99452E-02	4.09484E-03	-2.55015E-04	0.	0.
	4	0.	6.61513E-02	7.20526E-03	-3.70625E-04	0.	0.
	5	0.	-4.97430E-03	-4.95318E-02	2.05470E-08	0.	0.
	6	0.	4.49704E-02	-4.54369E-02	-2.55795E-04	0.	0.
	7	0.	4.61814E-02	-3.32057E-02	-2.55000E-04	0.	0.
	8	0.	1.99978E-02	-4.74844E-02	-1.27857E-04	0.	0.
	9	0.	4.76476E-02	-1.64670E-02	-2.55600E-04	0.	0.
	10	0.	6.11765E-02	-4.23265E-02	-3.70607E-04	0.	0.
	11	0.	6.23875E-02	-3.00953E-02	-3.70612E-04	0.	0.
	12	0.	2.81008E-02	-4.59241E-02	-1.65243E-04	0.	0.
	13	0.	6.38537E-02	-1.53572E-02	-3.70619E-04	0.	0.
4	1	0.	-9.44612E-10	-2.59886E-09	-8.59120E-42	0.	0.
	2	0.	-9.30388E-10	-2.52285E-09	-8.46183E-42	0.	0.
	3	0.	1.11617E-09	1.19025E-09	1.01515E-41	0.	0.
	4	0.	1.50145E-09	1.72483E-09	1.35550E-41	0.	0.
	5	0.	-1.87500E-09	-5.11971E-09	-1.70530E-41	0.	0.
	6	0.	-7.56826E-10	-3.92946E-09	-6.90150E-42	0.	0.
	7	0.	-2.93634E-10	-2.66803E-09	-2.67056E-42	0.	0.
	8	0.	-1.31691E-09	-4.52458E-09	-1.19773E-41	0.	0.
	9	0.	2.66022E-10	-1.14642E-09	2.41945E-42	0.	0.
	10	0.	-5.73554E-10	-3.39508E-09	-3.39746E-42	0.	0.
	11	0.	9.16396E-11	-2.13365E-09	6.33457E-43	0.	0.
	12	0.	-1.12426E-09	-4.25739E-09	-1.02252E-41	0.	0.
	13	0.	6.51295E-10	-6.12537E-10	5.92549E-42	0.	0.
3	1	0.	-3.78326E-06	-1.95560E-02	1.72065E-34	0.	0.
	2	0.	-3.58923E-06	-1.91657E-02	1.68011E-34	0.	0.
	3	0.	7.01115E-02	6.22275E-06	-3.61348E-35	0.	0.
	4	0.	1.10454E-01	1.71395E-05	-6.85284E-35	0.	0.
	5	0.	-7.37244E-06	-3.67217E-02	3.40878E-34	0.	0.
	6	0.	7.61041E-02	-3.67135E-02	3.04742E-34	0.	0.
	7	0.	7.61059E-02	-2.91306E-02	2.20337E-34	0.	0.
	8	0.	3.90484E-02	-3.87176E-02	3.22611E-34	0.	0.
	9	0.	7.61061E-02	-1.75921E-02	1.16724E-34	0.	0.
	10	0.	1.10446E-01	-3.87046E-02	2.72351E-34	0.	0.
	11	0.	1.10446E-01	-2.41217E-02	1.07945E-34	0.	0.
	12	0.	5.52194E-02	-3.67131E-02	3.06016E-34	0.	0.
	13	0.	1.10450E-01	-1.75832E-02	6.63501E-35	0.	0.
2	1	0.	-2.55225E-03	-1.59009E-02	1.31303E-08	0.	0.
	2	0.	-2.42136E-03	-1.56080E-02	1.24626E-08	0.	0.
	3	0.	5.35731E-02	4.11137E-06	-2.71221E-04	0.	0.
	4	0.	6.61104E-02	8.56975E-06	-3.63519E-04	0.	0.
	5	0.	-4.97361E-03	-3.15089E-02	2.55969E-08	0.	0.
	6	0.	4.85995E-02	-3.15046E-02	-2.71195E-04	0.	0.
	7	0.	4.46102E-02	-2.37009E-02	-2.71201E-04	0.	0.
	8	0.	2.16129E-02	-3.15088E-02	-1.35585E-04	0.	0.
	9	0.	5.12761E-02	-1.43067E-02	-2.71204E-04	0.	0.
	10	0.	6.31368E-02	-3.15003E-02	-3.83444E-04	0.	0.
	11	0.	6.43475E-02	-2.36963E-02	-3.83500E-04	0.	0.
	12	0.	2.90818E-02	-3.15046E-02	-1.91734E-04	0.	0.
	13	0.	6.55134E-02	-1.43022E-02	-3.83504E-04	0.	0.

1	1	0.	-5.29335E-14	-7.96602E-10	-7.48622E-47	0.	0.
	2	0.	-3.12446E-14	-7.77147E-10	-7.10414E-47	0.	0.
	3	0.	1.20190E-10	2.04712E-13	2.80424E-43	0.	0.
	4	0.	1.66370E-13	4.26702E-13	3.78202E-46	0.	0.
	5	0.	-6.41701E-14	-1.57375E-09	-1.45924E-46	0.	0.
	6	0.	1.20126E-10	-1.57354E-09	2.86774E-43	0.	0.
	7	0.	1.20142E-10	-1.18447E-09	2.86815E-43	0.	0.
	8	0.	6.30310E-11	-1.57365E-09	1.43310E-43	0.	0.
	9	0.	1.20101E-10	-7.16757E-10	2.86855E-43	0.	0.
	10	0.	1.02172E-13	-1.57332E-09	2.52554E-46	0.	0.
	11	0.	1.17814E-13	-1.18475E-09	2.87074E-46	0.	0.
	12	0.	1.90069E-14	-1.57354E-09	4.32107E-47	0.	0.
	13	0.	1.36730E-13	-7.16515E-10	3.10883E-46	0.	0.

.....BEAM FORCES AND MOMENTS

GROUP I COLUMNS

BEAM LOAD NU, NU,	AXIAL K1	SHEAR K2	SHEAR K3	TORSION M1	BENDING K2	BENDING M3
1	1 79.173E-01 -79.173E-01	32.934E-05 32.934E-05	0. 0.	0. 0.	0. 0.	0. -47.424E-03
1	2 77.715E-01 -77.715E-01	31.245E-05 31.245E-05	0. 0.	0. 0.	0. 0.	0. -44.992E-03
1	3-20.471E-04 20.471E-04	18.747E-04 18.747E-04	0. 0.	0. 0.	0. 0.	0. 28.995E-02
1	4-42.670E-04 42.670E-04	18.637E-04 18.637E-04	0. 0.	0. 0.	0. 0.	0. 23.957E-02
1	5 15.884E+00 -15.884E+00	64.178E-05 64.178E-05	0. 0.	0. 0.	0. 0.	0. -92.410E-03
1	6 15.887E+00 -15.887E+00	12.329E-04 12.329E-04	0. 0.	0. 0.	0. 0.	0. 17.754E-02
1	7 11.801E+00 -11.801E+00	13.891E-04 13.891E-04	0. 0.	0. 0.	0. 0.	0. 20.003E-02
1	8 15.888E+00 -15.888E+00	29.555E-05 29.555E-05	0. 0.	0. 0.	0. 0.	0. 42.560E-03
1	9 71.235E-01 -71.235E-01	15.783E-04 15.783E-04	0. 0.	0. 0.	0. 0.	0. 22.727E-02
1	10 15.885E+00 -15.885E+00	10.210E-04 10.214E-04	0. 0.	0. 0.	0. 0.	0. 14.710E-02
1	11 11.744E+00 -11.744E+00	11.781E-04 11.781E-04	0. 0.	0. 0.	0. 0.	0. 18.965E-02
1	12 15.887E+00 -15.887E+00	19.007E-05 19.007E-05	0. 0.	0. 0.	0. 0.	0. 27.370E-03
1	13 71.213E-01 -71.213E-01	13.673E-04 13.673E-04	0. 0.	0. 0.	0. 0.	0. 19.889E-02
2	1 18.199E-01 -18.199E-01	32.934E-05 32.934E-05	0. 0.	0. 0.	0. 0.	0. -47.424E-03
2	2 17.715E-01 -17.715E-01	31.245E-05 31.245E-05	0. 0.	0. 0.	0. 0.	0. -44.992E-03
2	3-20.471E-04 20.471E-04	18.747E-04 18.747E-04	0. 0.	0. 0.	0. 0.	0. 28.995E-02
2	4-42.670E-04 42.670E-04	18.637E-04 18.637E-04	0. 0.	0. 0.	0. 0.	0. 23.957E-02
2	5 35.918E-01 -35.918E-01	64.178E-05 64.178E-05	0. 0.	0. 0.	0. 0.	0. -92.410E-03

2	6	35.693E-01	-12.329E-04	0.	0.	0.	-17.754E-02
		-35.693E-01	12.329E-04	0.	0.	0.	0.
2	7	27.036E-01	-15.691E-04	0.	0.	0.	-20.003E-02
		-27.036E-01	15.691E-04	0.	0.	0.	0.
2	8	35.904E-01	-24.555E-05	0.	0.	0.	-42.560E-03
		-35.904E-01	24.555E-05	0.	0.	0.	0.
2	9	16.354E-01	-15.783E-04	0.	0.	0.	-22.727E-02
		-16.354E-01	15.783E-04	0.	0.	0.	0.
2	10	35.671E-01	-10.219E-04	0.	0.	0.	-14.716E-02
		-35.671E-01	10.219E-04	0.	0.	0.	0.
2	11	27.014E-01	-11.781E-04	0.	0.	0.	-10.465E-02
		-27.014E-01	11.781E-04	0.	0.	0.	0.
2	12	35.893E-01	-14.007E-05	0.	0.	0.	-27.370E-03
		-35.893E-01	14.007E-05	0.	0.	0.	0.
2	13	16.337E-01	-15.673E-04	0.	0.	0.	-14.689E-02
		-16.337E-01	15.673E-04	0.	0.	0.	0.

.....BEAM FORCES AND MOMENTS

GROUP 2 COLUMNS

BEAM LOAD NO. NO.	AXIAL R1	SHEAR R2	SHEAR R3	TORSION M1	BENDING P2	BENDING M3
1 1	16.228E+00	-10.123E-04	0.	0.	0.	0.
	-16.228E+00	10.123E-04	0.	0.	0.	-14.577E-02
1 2	17.786E+00	-46.035E-05	0.	0.	0.	0.
	-17.786E+00	46.035E-05	0.	0.	0.	-13.829E-02
1 3	29.773E+01	-52.006E-04	0.	0.	0.	0.
	-29.773E+01	52.006E-04	0.	0.	0.	74.889E-02
1 4	52.388E+01	-50.709E-04	0.	0.	0.	0.
	-52.388E+01	50.709E-04	0.	0.	0.	73.021E-02
1 5	36.014E+00	-14.726E-04	0.	0.	0.	0.
	-36.014E+00	14.726E-04	0.	0.	0.	-28.406E-02
1 6	33.036E+00	-32.280E-04	0.	0.	0.	0.
	-33.036E+00	32.280E-04	0.	0.	0.	48.485E-02
1 7	24.143E+00	-37.082E-04	0.	0.	0.	0.
	-24.143E+00	37.082E-04	0.	0.	0.	33.397E-02
1 8	34.525E+00	-62.788E-05	0.	0.	0.	0.
	-34.525E+00	62.788E-05	0.	0.	0.	40.388E-03
1 9	13.427E+00	-42.898E-04	0.	0.	0.	0.
	-13.427E+00	42.898E-04	0.	0.	0.	61.770E-02
1 10	30.775E+00	-30.983E-04	0.	0.	0.	0.
	-30.775E+00	30.983E-04	0.	0.	0.	44.615E-02
1 11	21.882E+00	-35.785E-04	0.	0.	0.	0.
	-21.882E+00	35.785E-04	0.	0.	0.	51.530E-02
1 12	33.394E+00	-56.284E-05	0.	0.	0.	0.
	-33.394E+00	56.284E-05	0.	0.	0.	81.048E-03
1 13	11.166E+00	-41.599E-04	0.	0.	0.	0.
	-11.166E+00	41.599E-04	0.	0.	0.	59.902E-02
2 1	16.228E+00	-10.123E-04	0.	0.	0.	0.
	-16.228E+00	10.123E-04	0.	0.	0.	-14.577E-02

2	2	17.786E+00	40.035E-05	0.	0.	0.	0.
		-17.786E+00	-40.035E-05	0.	0.	0.	13.824E-02
2	3	29.705E+01	50.127E-04	0.	0.	0.	0.
		-29.705E+01	-50.127E-04	0.	0.	0.	72.182E-02
2	4	52.388E+01	50.709E-04	0.	0.	0.	0.
		-52.388E+01	-50.709E-04	0.	0.	0.	73.021E-02
2	5	36.014E+00	14.726E-04	0.	0.	0.	0.
		-36.014E+00	-14.726E-04	0.	0.	0.	28.406E-02
2	6	36.990E+00	64.853E-04	0.	0.	0.	0.
		-36.990E+00	-64.853E-04	0.	0.	0.	10.059E-01
2	7	30.097E+00	65.051E-04	0.	0.	0.	0.
		-30.097E+00	-65.051E-04	0.	0.	0.	93.674E-02
2	8	37.502E+00	44.790E-04	0.	0.	0.	0.
		-37.502E+00	-44.790E-04	0.	0.	0.	64.497E-02
2	9	19.381E+00	54.237E-04	0.	0.	0.	0.
		-19.381E+00	-54.237E-04	0.	0.	0.	85.301E-02
2	10	41.253E+00	70.435E-04	0.	0.	0.	0.
		-41.253E+00	-70.435E-04	0.	0.	0.	10.143E-01
2	11	32.354E+00	65.634E-04	0.	0.	0.	0.
		-32.354E+00	-65.634E-04	0.	0.	0.	92.512E-02
2	12	38.633E+00	45.081E-04	0.	0.	0.	0.
		-38.633E+00	-45.081E-04	0.	0.	0.	64.910E-02
2	13	21.644E+00	54.820E-04	0.	0.	0.	0.
		-21.644E+00	-54.820E-04	0.	0.	0.	86.140E-02
3	1	52.043E+01	10.123E-04	0.	0.	0.	14.577E-02
		-52.043E+01	-10.123E-04	0.	0.	0.	0.
3	2	51.372E+01	40.035E-05	0.	0.	0.	13.829E-02
		-51.372E+01	-40.035E-05	0.	0.	0.	0.
3	3	34.613E+04	52.006E-04	0.	0.	0.	-74.864E-02
		-34.613E+04	-52.006E-04	0.	0.	0.	0.
3	4	85.340E+04	50.709E-04	0.	0.	0.	-73.021E-02
		-85.340E+04	-50.709E-04	0.	0.	0.	0.
3	5	10.346E+00	14.726E-04	0.	0.	0.	28.406E-02
		-10.346E+00	-14.726E-04	0.	0.	0.	0.
3	6	10.350E+00	52.280E-04	0.	0.	0.	-46.463E-02
		-10.350E+00	-52.280E-04	0.	0.	0.	0.
3	7	77.614E+01	37.082E-04	0.	0.	0.	-53.397E-02
		-77.614E+01	-37.082E-04	0.	0.	0.	0.
3	8	10.346E+00	62.768E-05	0.	0.	0.	-90.386E-03
		-10.346E+00	-62.768E-05	0.	0.	0.	0.
3	9	46.918E+01	42.896E-04	0.	0.	0.	-61.770E-02
		-46.918E+01	-42.896E-04	0.	0.	0.	0.
3	10	10.355E+00	30.983E-04	0.	0.	0.	-44.615E-02
		-10.355E+00	-30.983E-04	0.	0.	0.	0.
3	11	77.664E+01	35.785E-04	0.	0.	0.	-51.530E-02
		-77.664E+01	-35.785E-04	0.	0.	0.	0.
3	12	10.351E+00	50.284E-05	0.	0.	0.	-81.088E-03
		-10.351E+00	-50.284E-05	0.	0.	0.	0.
3	13	46.969E+01	41.599E-04	0.	0.	0.	-59.902E-02
		-46.969E+01	-41.599E-04	0.	0.	0.	0.

4	1	52.093E-01	-10.123E-04	0.	0.	0.	-14.577E-02
		-52.093E-01	10.123E-04	0.	0.	0.	0.
4	2	51.372E-01	-40.035E-05	0.	0.	0.	-13.824E-02
		-51.372E-01	40.035E-05	0.	0.	0.	0.
4	3	62.375E-04	-50.127E-04	0.	0.	0.	-72.102E-02
		62.375E-04	50.127E-04	0.	0.	0.	0.
4	4	45.340E-04	-50.704E-04	0.	0.	0.	-73.021E-02
		45.340E-04	50.704E-04	0.	0.	0.	0.
4	5	10.340E+00	-14.720E-04	0.	0.	0.	-26.406E-02
		-10.340E+00	14.720E-04	0.	0.	0.	0.
4	6	10.340E+00	-64.853E-04	0.	0.	0.	-10.059E-01
		-10.340E+00	64.853E-04	0.	0.	0.	0.
4	7	77.717E-01	-65.051E-04	0.	0.	0.	-93.674E-02
		-77.717E-01	65.051E-04	0.	0.	0.	0.
4	8	10.343E+00	-44.790E-04	0.	0.	0.	-64.497E-02
		-10.343E+00	44.790E-04	0.	0.	0.	0.
4	9	46.021E-01	-54.237E-04	0.	0.	0.	-85.301E-02
		-46.021E-01	54.237E-04	0.	0.	0.	0.
4	10	10.338E+00	-70.435E-04	0.	0.	0.	-10.143E-01
		-10.338E+00	70.435E-04	0.	0.	0.	0.
4	11	77.694E-01	-65.034E-04	0.	0.	0.	-94.512E-02
		-77.694E-01	65.034E-04	0.	0.	0.	0.
4	12	10.342E+00	-45.081E-04	0.	0.	0.	-64.916E-02
		-10.342E+00	45.081E-04	0.	0.	0.	0.
4	13	46.798E-01	-54.820E-04	0.	0.	0.	-86.140E-02
		-46.798E-01	54.820E-04	0.	0.	0.	0.

.....BEAM FORCES AND MOMENTS

GROUP 3 COLUMNS

BEAM LOAD NO.	AXIAL NO.	AXIAL H1	SHEAR H2	SHEAR R1	TENSION M1	BENDING M2	BENDING M3
1	1	79.173E-01	32.934E-05	0.	0.	0.	0.
		-79.173E-01	-32.934E-05	0.	0.	0.	47.424E-03
1	2	77.715E-01	31.245E-05	0.	0.	0.	0.
		-77.715E-01	-31.245E-05	0.	0.	0.	44.992E-03
1	3	28.023E-04	17.520E-04	0.	0.	0.	0.
		-28.023E-04	-17.520E-04	0.	0.	0.	25.220E-02
1	4	42.670E-04	10.637E-04	0.	0.	0.	0.
		-42.670E-04	-10.637E-04	0.	0.	0.	23.457E-02
1	5	15.684E+00	64.178E-05	0.	0.	0.	0.
		-15.684E+00	-64.178E-05	0.	0.	0.	92.410E-03
1	6	15.692E+00	23.937E-04	0.	0.	0.	0.
		-15.692E+00	-23.937E-04	0.	0.	0.	34.470E-02
1	7	11.806E+00	22.375E-04	0.	0.	0.	0.
		-11.806E+00	-22.375E-04	0.	0.	0.	32.220E-02
1	8	15.690E+00	15.178E-04	0.	0.	0.	0.
		-15.690E+00	-15.178E-04	0.	0.	0.	21.656E-02
1	9	71.284E-01	20.484E-04	0.	0.	0.	0.
		-71.284E-01	-20.484E-04	0.	0.	0.	24.490E-02
1	10	15.693E+00	23.055E-04	0.	0.	0.	0.
		-15.693E+00	-23.055E-04	0.	0.	0.	33.194E-02

1	11	11,807E+00	21,443E-04	0.	0.	0.	0.
		-11,807E+00	-21,443E-04	0.	0.	0.	30,949E-02
1	12	15,691E+00	14,736E-04	0.	0.	0.	0.
		-15,691E+00	-14,736E-04	0.	0.	0.	21,220E-02
1	13	71,299E+01	14,601E-04	0.	0.	0.	0.
		-71,299E+01	-14,601E-04	0.	0.	0.	28,225E-02
2	1	16,194E+01	32,934E-05	0.	0.	0.	-47,424E-03
		-16,194E+01	-32,934E-05	0.	0.	0.	0.
2	2	17,715E+01	31,245E-05	0.	0.	0.	-44,992E-03
		-17,715E+01	-31,245E-05	0.	0.	0.	0.
2	3	26,023E+04	17,520E-04	0.	0.	0.	-25,228E-02
		-26,023E+04	-17,520E-04	0.	0.	0.	0.
2	4	42,670E+04	16,637E-04	0.	0.	0.	-23,957E-02
		-42,670E+04	-16,637E-04	0.	0.	0.	0.
2	5	35,914E+01	64,178E-05	0.	0.	0.	-92,410E-03
		-35,914E+01	-64,178E-05	0.	0.	0.	0.
2	6	35,942E+01	23,937E-04	0.	0.	0.	-34,470E-02
		-35,942E+01	-23,937E-04	0.	0.	0.	0.
2	7	27,085E+01	22,375E-04	0.	0.	0.	-32,220E-02
		-27,085E+01	-22,375E-04	0.	0.	0.	0.
2	8	35,928E+01	15,178E-04	0.	0.	0.	-21,450E-02
		-35,928E+01	-15,178E-04	0.	0.	0.	0.
2	9	16,407E+01	20,484E-04	0.	0.	0.	-29,498E-02
		-16,407E+01	-20,484E-04	0.	0.	0.	0.
2	10	35,957E+01	23,055E-04	0.	0.	0.	-33,199E-02
		-35,957E+01	-23,055E-04	0.	0.	0.	0.
2	11	27,099E+01	21,443E-04	0.	0.	0.	-30,949E-02
		-27,099E+01	-21,443E-04	0.	0.	0.	0.
2	12	35,935E+01	14,736E-04	0.	0.	0.	-21,220E-02
		-35,935E+01	-14,736E-04	0.	0.	0.	0.
2	13	16,422E+01	14,601E-04	0.	0.	0.	-28,225E-02
		-16,422E+01	-14,601E-04	0.	0.	0.	0.

.....BEAM FORCES AND MOMENTS

GROUP 4 ROOF BEAMS

BEAM NO.	LOAD NO.	AXIAL R1	SHEAR R2	SHEAR R3	TORSION M1	BENDING M2	BENDING M3
1	1	32,934E+05	17,712E+01	0.	0.	0.	0.
		32,934E+05	27,288E+01	0.	0.	0.	-86,180E+00
1	2	31,245E+05	17,715E+01	0.	0.	0.	0.
		31,245E+05	27,285E+01	0.	0.	0.	-86,135E+00
1	3	19,595E+01	20,471E+04	0.	0.	0.	0.
		-19,595E+01	-20,471E+04	0.	0.	0.	-36,648E+02
1	4	16,348E+01	42,670E+04	0.	0.	0.	0.
		-16,348E+01	-42,670E+04	0.	0.	0.	-76,808E+02
1	5	64,178E+05	35,427E+01	0.	0.	0.	0.
		64,178E+05	54,573E+01	0.	0.	0.	-17,232E+01
1	6	19,588E+01	35,408E+01	0.	0.	0.	0.
		-19,588E+01	-35,408E+01	0.	0.	0.	-17,280E+01

1	7	19,590E=01 -19,590E=01	20,549E=01 40,951E=01	0, 0,	0, 0,	0, 0,	0, -12,962E+01
1	8	97,409E=02 -97,409E=02	35,417E=01 54,583E=01	0, 0,	0, 0,	0, 0,	0, -17,250E+01
1	4	19,592E=01 -19,592E=01	15,921E=01 24,579E=01	0, 0,	0, 0,	0, 0,	0, -77,930E+00
1	10	15,391E=01 -15,391E=01	35,384E=01 54,616E=01	0, 0,	0, 0,	0, 0,	0, -17,306E+01
1	11	10,393E=01 -10,393E=01	26,527E=01 40,973E=01	0, 0,	0, 0,	0, 0,	0, -13,002E+01
1	12	81,925E=02 -81,925E=02	35,406E=01 54,594E=01	0, 0,	0, 0,	0, 0,	0, -17,270E+01
1	13	10,395E=01 -10,395E=01	15,698E=01 24,602E=01	0, 0,	0, 0,	0, 0,	0, -76,330E+00
2	1	13,416E=04 13,416E=04	24,094E=01 20,906E=01	0, 0,	0, 0,	0, 0,	86,180E+00 -57,484E+00
2	2	12,728E=04 12,728E=04	24,086E=01 20,914E=01	0, 0,	0, 0,	0, 0,	86,135E+00 -57,581E+00
2	3	33,596E=01 -33,596E=01	14,142E=04 -14,142E=04	0, 0,	0, 0,	0, 0,	36,840E=02 -11,393E=02
2	4	49,211E=01 -49,211E=01	42,670E=04 -42,670E=04	0, 0,	0, 0,	0, 0,	76,806E=02 63,449E=15
2	5	26,144E=04 26,144E=04	48,181E=01 41,819E=01	0, 0,	0, 0,	0, 0,	17,232E+01 -11,506E+01
2	6	33,572E=01 -33,572E=01	40,145E=01 41,855E=01	0, 0,	0, 0,	0, 0,	17,266E+01 -11,518E+01
2	7	33,578E=01 -33,578E=01	36,152E=01 31,348E=01	0, 0,	0, 0,	0, 0,	12,462E+01 -86,388E+00
2	8	16,773E=01 -16,773E=01	40,188E=01 41,812E=01	0, 0,	0, 0,	0, 0,	17,250E+01 -11,512E+01
2	9	33,596E=01 -33,596E=01	21,699E=01 18,801E=01	0, 0,	0, 0,	0, 0,	77,930E+00 -51,649E+00
2	10	49,185E=01 -49,185E=01	48,223E=01 41,777E=01	0, 0,	0, 0,	0, 0,	17,308E+01 -11,506E+01
2	11	49,191E=01 -49,191E=01	36,180E=01 31,320E=01	0, 0,	0, 0,	0, 0,	13,002E+01 -86,274E+00
2	12	24,574E=01 -24,574E=01	40,202E=01 41,798E=01	0, 0,	0, 0,	0, 0,	17,270E+01 -11,506E+01
2	13	49,194E=01 -49,194E=01	21,727E=01 18,773E=01	0, 0,	0, 0,	0, 0,	76,330E+00 -51,736E+00
3	1	13,416E=04 13,416E=04	24,094E=01 20,906E=01	0, 0,	0, 0,	0, 0,	57,484E+00 -86,180E+00
3	2	12,728E=04 12,728E=04	24,086E=01 20,914E=01	0, 0,	0, 0,	0, 0,	57,581E+00 -86,135E+00
3	3	33,595E=01 20,995E=01	34,352E=04 -34,352E=04	0, 0,	0, 0,	0, 0,	11,393E=02 50,441E=02
3	4	49,211E=01 49,211E=01	42,670E=04 -42,670E=04	0, 0,	0, 0,	0, 0,	-54,717E=15 76,806E=02

3	5=26.144E=04 26.144E=04	41.819E=01 46.161E=01	0. 0.	0. 0.	0. 0.	11.506E+01 -17.232E+01
3	6=27.021E=01 27.021E=01	41.854E=01 46.146E=01	0. 0.	0. 0.	0. 0.	11.518E+01 -17.161E+01
3	7=27.015E=01 27.015E=01	51.347E=01 56.103E=01	0. 0.	0. 0.	0. 0.	66.386E+00 -12.874E+01
3	8=13.524E=01 13.524E=01	41.637E=01 46.163E=01	0. 0.	0. 0.	0. 0.	11.512E+01 -17.206E+01
3	9=27.007E=01 27.007E=01	16.850E=01 21.650E=01	0. 0.	0. 0.	0. 0.	51.649E+00 -77.057E+00
3	10=49.237E=01 49.237E=01	41.862E=01 46.138E=01	0. 0.	0. 0.	0. 0.	11.506E+01 -17.155E+01
3	11=49.231E=01 49.231E=01	51.405E=01 56.095E=01	0. 0.	0. 0.	0. 0.	66.274E+00 -12.848E+01
3	12=24.632E=01 24.632E=01	41.841E=01 46.159E=01	0. 0.	0. 0.	0. 0.	11.506E+01 -17.193E+01
3	13=49.223E=01 49.223E=01	16.858E=01 21.642E=01	0. 0.	0. 0.	0. 0.	51.736E+00 -76.744E+00
4	1=32.934E=05 32.934E=05	27.288E=01 17.712E=01	0. 0.	0. 0.	0. 0.	66.180E+00 0.
4	2=31.245E=05 31.245E=05	27.245E=01 17.715E=01	0. 0.	0. 0.	0. 0.	66.135E+00 0.
4	3=12.493E=01 12.493E=01	-26.023E=04 26.023E=04	0. 0.	0. 0.	0. 0.	-50.441E=02 0.
4	4=16.398E=01 16.398E=01	-42.670E=04 42.670E=04	0. 0.	0. 0.	0. 0.	-76.609E=02 0.
4	5=64.178E=05 64.178E=05	54.573E=01 55.427E=01	0. 0.	0. 0.	0. 0.	17.232E+01 0.
4	6=13.000E=01 13.000E=01	54.545E=01 55.455E=01	0. 0.	0. 0.	0. 0.	17.161E+01 0.
4	7=12.446E=01 12.446E=01	46.902E=01 46.598E=01	0. 0.	0. 0.	0. 0.	12.874E+01 0.
4	8=65.031E=02 65.031E=02	54.554E=01 55.446E=01	0. 0.	0. 0.	0. 0.	17.206E+01 0.
4	9=12.496E=01 12.496E=01	24.531E=01 15.969E=01	0. 0.	0. 0.	0. 0.	77.057E+00 0.
4	10=16.404E=01 16.404E=01	54.530E=01 55.470E=01	0. 0.	0. 0.	0. 0.	17.155E+01 0.
4	11=16.403E=01 16.403E=01	46.866E=01 46.612E=01	0. 0.	0. 0.	0. 0.	12.848E+01 0.
4	12=62.053E=02 62.053E=02	54.552E=01 55.448E=01	0. 0.	0. 0.	0. 0.	17.193E+01 0.
4	13=16.401E=01 16.401E=01	24.516E=01 15.964E=01	0. 0.	0. 0.	0. 0.	76.744E+00 0.

.....BEAM FORCES AND MOMENTS

GROUP 5 2ND FLOOR BEAMS

BEAM NO.	LOAD NO.	AXIAL N1	SHEAR P2	SHEAR R3	TORSION M1	BENDING M2	BENDING M3
1	1	65.867E-05 -65.867E-05	60.000E-01 60.000E-01	0. 0.	0. 0.	0. 0.	0. 0.
1	2	62.489E-05 -62.489E-05	60.000E-01 60.000E-01	0. 0.	0. 0.	0. 0.	0. 0.
1	3	39.121E-01 -39.121E-01	-10.554E-16 10.554E-16	0. 0.	0. 0.	0. 0.	0. 0.
1	4	21.126E-01 -21.126E-01	-25.595E-16 25.595E-16	0. 0.	0. 0.	0. 0.	0. 0.
1	5	12.830E-04 -12.830E-04	12.000E+00 12.000E+00	0. 0.	0. 0.	0. 0.	0. 0.
1	6	39.134E-01 -39.134E-01	12.000E+00 12.000E+00	0. 0.	0. 0.	0. 0.	0. 0.
1	7	39.131E-01 -39.131E-01	40.000E-01 40.000E-01	0. 0.	0. 0.	0. 0.	0. 0.
1	8	19.573E-01 -19.573E-01	12.000E+00 12.000E+00	0. 0.	0. 0.	0. 0.	0. 0.
1	9	39.127E-01 -39.127E-01	54.000E-01 54.000E-01	0. 0.	0. 0.	0. 0.	0. 0.
1	10	21.139E-01 -21.139E-01	12.000E+00 12.000E+00	0. 0.	0. 0.	0. 0.	0. 0.
1	11	21.130E-01 -21.130E-01	40.000E-01 40.000E-01	0. 0.	0. 0.	0. 0.	0. 0.
1	12	10.576E-01 -10.576E-01	12.000E+00 12.000E+00	0. 0.	0. 0.	0. 0.	0. 0.
1	13	21.132E-01 -21.132E-01	54.000E-01 54.000E-01	0. 0.	0. 0.	0. 0.	0. 0.
2	1	27.528E-01 27.528E-01	45.577E-01 74.423E-01	0. 0.	0. 0.	0. 0.	0. -25.961E+01
2	2	26.117E-01 26.117E-01	45.577E-01 74.423E-01	0. 0.	0. 0.	0. 0.	0. -25.962E+01
2	3	10.419E+00 -10.419E+00	12.166E-07 -12.166E-07	0. 0.	0. 0.	0. 0.	0. 21.898E-05
2	4	12.893E+00 -12.893E+00	-32.190E-16 32.190E-16	0. 0.	0. 0.	0. 0.	0. -85.265E-15
2	5	53.645E-01 53.645E-01	41.154E-01 14.685E+00	0. 0.	0. 0.	0. 0.	0. -51.923E+01
2	6	50.547E-01 -50.547E-01	41.154E-01 14.685E+00	0. 0.	0. 0.	0. 0.	0. -51.923E+01
2	7	63.605E-01 -63.605E-01	68.366E-01 -11.143E+00	0. 0.	0. 0.	0. 0.	0. -38.942E+01
2	8	15.490E-02 15.490E-02	41.154E-01 14.685E+00	0. 0.	0. 0.	0. 0.	0. -51.923E+01
2	9	79.410E-01 -79.410E-01	41.020E-01 65.980E-01	0. 0.	0. 0.	0. 0.	0. -23.364E+01

2	10	75.290E=01	41.154E=01	0.	0.	0.	0.
		-75.290E=01	14.855E+00	0.	0.	0.	-51.923E+01
2	11	88.348E=01	88.368E=01	0.	0.	0.	0.
		-88.348E=01	11.163E+00	0.	0.	0.	-38.942E+01
2	12	10.822E=01	41.154E=01	0.	0.	0.	0.
		-10.822E=01	14.855E+00	0.	0.	0.	-51.923E+01
2	13	10.410E+00	41.020E=01	0.	0.	0.	0.
		-10.410E+00	88.980E=01	0.	0.	0.	-23.365E+01
3	1	27.526E=01	74.423E=01	0.	0.	0.	25.961E+01
		27.526E=01	45.577E=01	0.	0.	0.	0.
3	2	26.117E=01	74.423E=01	0.	0.	0.	25.962E+01
		26.117E=01	45.577E=01	0.	0.	0.	0.
3	3	41.023E=01	-12.168E=07	0.	0.	0.	-21.848E=05
		41.023E=01	12.168E=07	0.	0.	0.	0.
3	4	12.893E+00	-26.967E=16	0.	0.	0.	-10.284E=16
		12.893E+00	26.967E=16	0.	0.	0.	0.
3	5	53.845E=01	14.885E+00	0.	0.	0.	51.923E+01
		53.845E=01	41.154E=01	0.	0.	0.	0.
3	6	14.467E+00	14.885E+00	0.	0.	0.	51.923E+01
		14.467E+00	41.154E=01	0.	0.	0.	0.
3	7	13.161E+00	11.163E+00	0.	0.	0.	38.942E+01
		13.161E+00	88.368E=01	0.	0.	0.	0.
3	8	99.158E=01	14.885E+00	0.	0.	0.	51.923E+01
		99.158E=01	41.154E=01	0.	0.	0.	0.
3	9	11.580E+00	88.980E=01	0.	0.	0.	23.364E+01
		11.580E+00	41.020E=01	0.	0.	0.	0.
3	10	18.258E+00	14.885E+00	0.	0.	0.	51.923E+01
		18.258E+00	41.154E=01	0.	0.	0.	0.
3	11	16.952E+00	11.163E+00	0.	0.	0.	38.942E+01
		16.952E+00	88.368E=01	0.	0.	0.	0.
3	12	11.811E+00	14.885E+00	0.	0.	0.	51.923E+01
		11.811E+00	41.154E=01	0.	0.	0.	0.
3	13	15.371E+00	88.980E=01	0.	0.	0.	23.365E+01
		15.371E+00	41.020E=01	0.	0.	0.	0.
4	1	85.867E=05	88.000E=01	0.	0.	0.	0.
		-85.867E=05	88.000E=01	0.	0.	0.	0.
4	2	82.489E=05	88.000E=01	0.	0.	0.	0.
		-82.489E=05	88.000E=01	0.	0.	0.	0.
4	3	25.923E=01	-17.414E=16	0.	0.	0.	0.
		25.923E=01	17.414E=16	0.	0.	0.	0.
4	4	21.120E=01	-25.058E=16	0.	0.	0.	0.
		21.120E=01	25.058E=16	0.	0.	0.	0.
4	5	12.838E=04	12.000E+00	0.	0.	0.	0.
		-12.838E=04	12.000E+00	0.	0.	0.	0.
4	6	25.910E=01	12.000E+00	0.	0.	0.	0.
		25.910E=01	12.000E+00	0.	0.	0.	0.
4	7	25.913E=01	88.000E=01	0.	0.	0.	0.
		25.913E=01	88.000E=01	0.	0.	0.	0.

4	8=12.944E-01	12.000E+00	0.	0.	0.	0.
	12.944E-01	12.000E+00	0.	0.	0.	0.
4	9=25.917E-01	54.000E-01	0.	0.	0.	0.
	25.917E-01	54.000E-01	0.	0.	0.	0.
4	10=21.113E-01	12.000E+00	0.	0.	0.	0.
	21.113E-01	12.000E+00	0.	0.	0.	0.
4	11=21.116E-01	90.000E-01	0.	0.	0.	0.
	21.116E-01	90.000E-01	0.	0.	0.	0.
4	12=10.550E-01	12.000E+00	0.	0.	0.	0.
	10.550E-01	12.000E+00	0.	0.	0.	0.
4	13=21.120E-01	54.000E-01	0.	0.	0.	0.
	21.120E-01	54.000E-01	0.	0.	0.	0.

GROUP #6 "K" BRACE

TRUSS MEMBER ACTIONS

MEMBER	LOAD	STRESS	FORCE
1	1	-5.46580	-12.096
1	2	-3.41363	-11.914
1	3	4.09379	14.287
1	4	5.50756	19.221
1	5	-6.87443	-24.009
1	6	-2.78564	-9.722
1	7	-1.07882	-3.765
1	8	-4.83253	-16.866
1	9	.97457	3.401
1	10	-1.37185	-4.788
1	11	.33495	1.169
1	12	-4.12564	-14.398
1	13	2.38634	8.335
2	1	-1.01111	-3.529
2	2	-.95926	-3.348
2	3	1.36720	4.772
2	4	2.40684	6.400
2	5	-1.97037	-6.877
2	6	-.60317	-2.105
2	7	-.12354	-.431
2	8	-1.28577	-4.491
2	9	.45720	1.596
2	10	.43647	1.523
2	11	.91610	3.197
2	12	-.76695	-2.677
2	13	1.49684	5.224

3	1	=3,46580	=12,096
3	2	=3,41363	=11,914
3	3	=4,09379	=14,287
3	4	=5,50756	=19,221
3	5	=6,87943	=24,009
3	6	=10,97321	=38,297
3	7	=9,26640	=32,340
3	8	=8,92632	=31,153
3	9	=7,21501	=25,173
3	10	=12,38699	=43,231
3	11	=10,68018	=37,274
3	12	=9,63321	=33,620
3	13	=8,62678	=30,107

4	1	=1,01111	=3,529
4	2	=0,95926	=3,348
4	3	=1,36813	=4,775
4	4	=2,40684	=8,400
4	5	=1,97037	=6,877
4	6	=3,33850	=11,651
4	7	=2,85887	=9,977
4	8	=2,65444	=9,264
4	9	=2,27813	=7,951
4	10	=4,37721	=15,276
4	11	=3,89758	=13,603
4	12	=3,17379	=11,077
4	13	=3,31684	=11,576

BOUNDARY ELEMENT FORCES / MOMENTS

ELEMENT NUMBER	LOAD CASE	FORCE	MOMENT
1	1	7,96602E+00	0.
1	2	7,77147E+00	0.
1	3	=2,04712E+03	0.
1	4	=4,26702E+03	0.
1	5	1,57375E+01	0.
1	6	1,57354E+01	0.
1	7	1,18447E+01	0.
1	8	1,57365E+01	0.
1	9	7,16737E+00	0.
1	10	1,57332E+01	0.

1	11	1.18475E+01	0.
1	12	1.57354E+01	0.
1	13	7.16515E+00	0.
2	1	-3.29335E-04	0.
2	2	-3.12446E-04	0.
2	3	1.26190E+00	0.
2	4	1.66370E-03	0.
2	5	-6.41781E-04	0.
2	6	1.26120E+00	0.
2	7	1.26142E+00	0.
2	8	6.30310E-01	0.
2	9	1.26161E+00	0.
2	10	1.02192E-03	0.
2	11	1.17614E-03	0.
2	12	1.90069E-04	0.
2	13	1.36730E-03	0.
3	1	2.59686E+01	0.
3	2	2.52285E+01	0.
3	3	-1.19025E+01	0.
3	4	-1.72463E+01	0.
3	5	5.11971E+01	0.
3	6	3.92946E+01	0.
3	7	2.66803E+01	0.
3	8	4.52458E+01	0.
3	9	1.14692E+01	0.
3	10	3.39508E+01	0.
3	11	2.13365E+01	0.
3	12	4.25739E+01	0.
3	13	6.12537E+00	0.
4	1	-9.44612E+00	0.
4	2	-9.30368E+00	0.
4	3	1.11617E+01	0.
4	4	1.50145E+01	0.
4	5	-1.87500E+01	0.
4	6	-7.58828E+00	0.
4	7	-2.93634E+00	0.
4	8	-1.31641E+01	0.
4	9	2.66022E+00	0.
4	10	-5.73554E+00	0.
4	11	9.16396E-01	0.
4	12	-1.12428E+01	0.
4	13	6.51295E+00	0.

5	1	2.59686E+01	0.
5	2	2.52285E+01	0.
5	3	1.19018E+01	0.
5	4	1.72463E+01	0.
5	5	5.11971E+01	0.
5	6	6.30989E+01	0.
5	7	5.04846E+01	0.
5	8	5.71480E+01	0.
5	9	3.52735E+01	0.
5	10	6.84434E+01	0.
5	11	5.58292E+01	0.
5	12	5.98203E+01	0.
5	13	4.06180E+01	0.
<hr/>			
6	1	9.44612E+00	0.
6	2	9.30388E+00	0.
6	3	1.11615E+01	0.
6	4	1.50145E+01	0.
6	5	1.67500E+01	0.
6	6	2.99115E+01	0.
6	7	2.52596E+01	0.
6	8	2.43308E+01	0.
6	9	1.96630E+01	0.
6	10	3.37645E+01	0.
6	11	2.91125E+01	0.
6	12	2.62572E+01	0.
6	13	2.35150E+01	0.
<hr/>			
7	1	7.96602E+00	0.
7	2	7.77147E+00	0.
7	3	2.80228E+03	0.
7	4	4.26702E+03	0.
7	5	1.57375E+01	0.
7	6	1.57403E+01	0.
7	7	1.18546E+01	0.
7	8	1.57389E+01	0.
7	9	7.17222E+00	0.
7	10	1.57418E+01	0.
7	11	1.18560E+01	0.
7	12	1.57396E+01	0.
7	13	7.17368E+00	0.

AD-A031 252

ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 9/2
CORPS-WIDE CONFERENCE ON COMPUTER-AIDED DESIGN IN STRUCTURAL EN--ETC(U)
AUG 76 W D ASHTON, D REYNOLDS, D B BALDWIN

UNCLASSIFIED

NL

2 OF 3
AD
A031252



8	1	3.29335E-04	0.
8	2	3.12446E-04	0.
8	3	5.01768E-01	0.
8	4	1.86370E-03	0.
8	5	5.41781E-04	0.
8	6	5.02410E-01	0.
8	7	5.02253E-01	0.
8	8	3.01528E-01	0.
8	9	5.02064E-01	0.
8	10	2.30548E-03	0.
8	11	2.14926E-03	0.
8	12	1.47363E-03	0.
8	13	1.96010E-03	0.

STATIC SOLUTION TIME LOG

EQUATION SOLUTION	=	.03
DISPLACEMENT OUTPUT	=	.07
STRESS RECOVERY	=	.18

OVERALL TIME LOG

NODAL POINT INPUT	=	.02
ELEMENT STIFFNESS FORMATION	=	.14
NODAL LOAD INPUT	=	.00
TOTAL STIFFNESS FORMATION	=	.04
STATIC ANALYSIS	=	.29
EIGENVALUE EXTRACTION	=	0.00
FORCED RESPONSE ANALYSIS	=	0.00
RESPONSE SPECTRUM ANALYSIS	=	0.00
STEP-BY-STEP INTEGRATION	=	0.00
TOTAL SOLUTION TIME	=	.50

PROJECT 2-D FRAME SAMPLE PROBLEM
 ITEM SAP III

SHEET NO. OF SHEETS

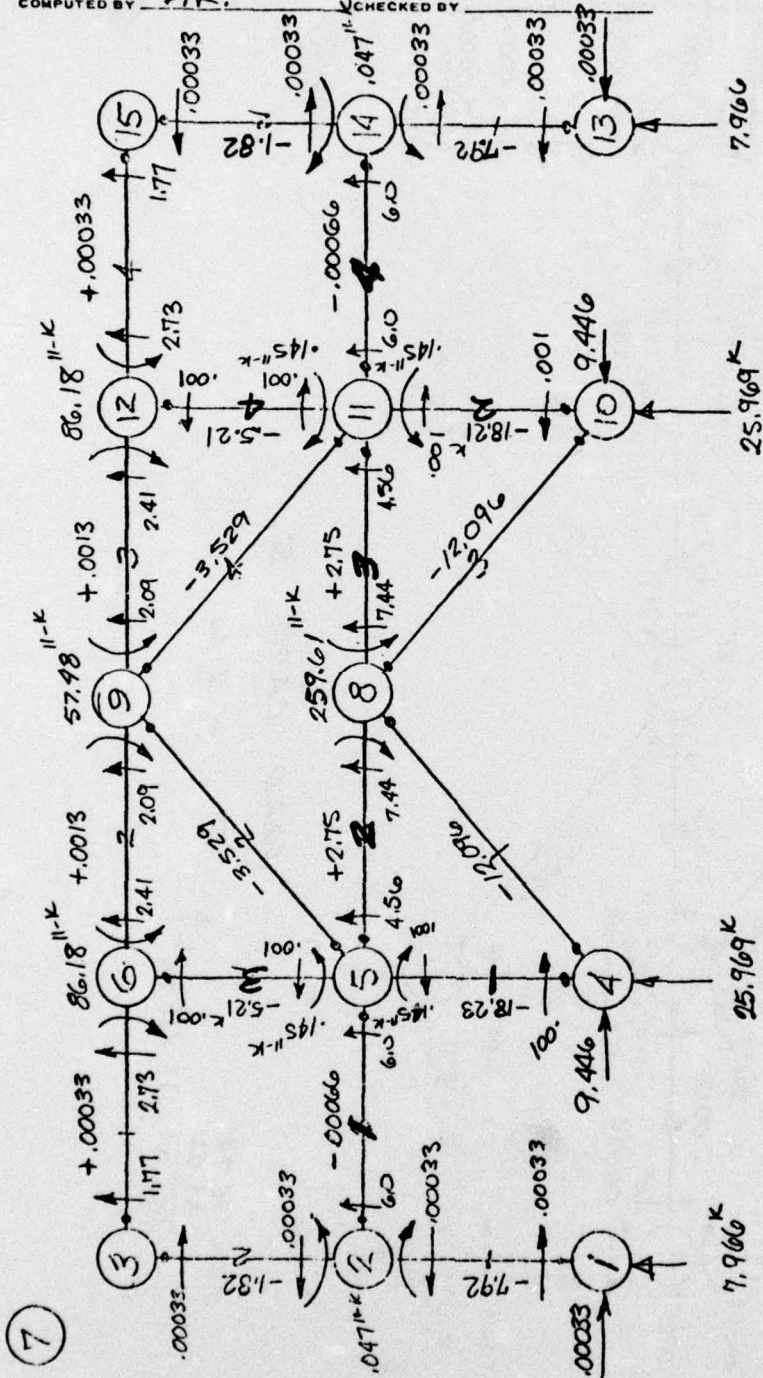
DATE 19

FILE

REF. DRWG. NO.

COMPUTED BY DKR.

CHECKED BY



LOAD CASE 1
P.L. (ONLY.)

$$\Sigma V = 7.966 + \frac{25.969}{(33.935)(2)} = 67.87 \text{ k}$$

PROJECT 2-D FRAME SAMPLE FRAME
ITEM SAP IV

SHEET NO. ____ OF ____ SHEETS

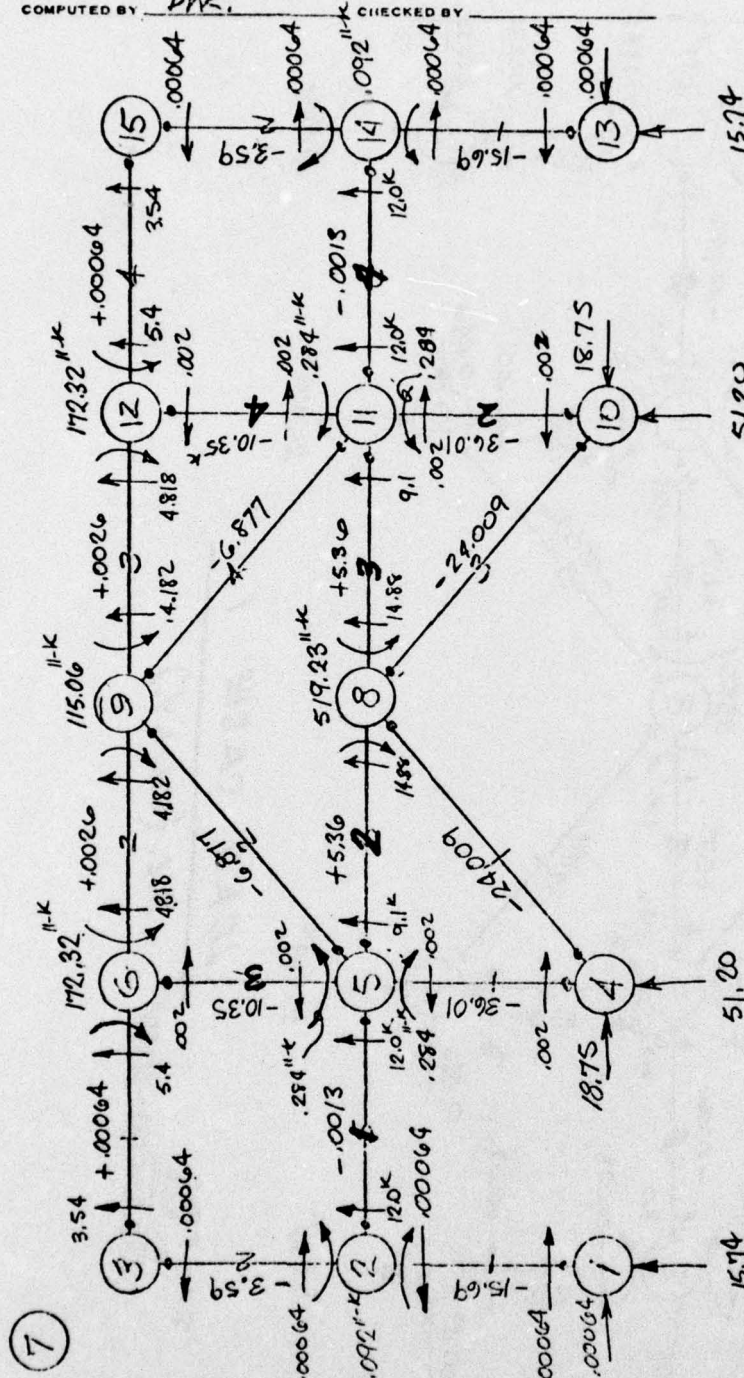
DATE _____, 19____

FILE _____

REF. DRWG. NO. _____

COMPUTED BY DNR.

CHECKED BY _____



LOAD CASE = S

D.L. + L.L.

$$\Sigma V = \frac{15.74}{51.20} \uparrow$$

$$\frac{(66.94)(2)}{(66.94)(2)} = 133.88 \text{ K} \uparrow$$

PROJECT 2-D FRAME SAMPLE FRAME
ITEM SAP IV

COMPUTED BY DWR.

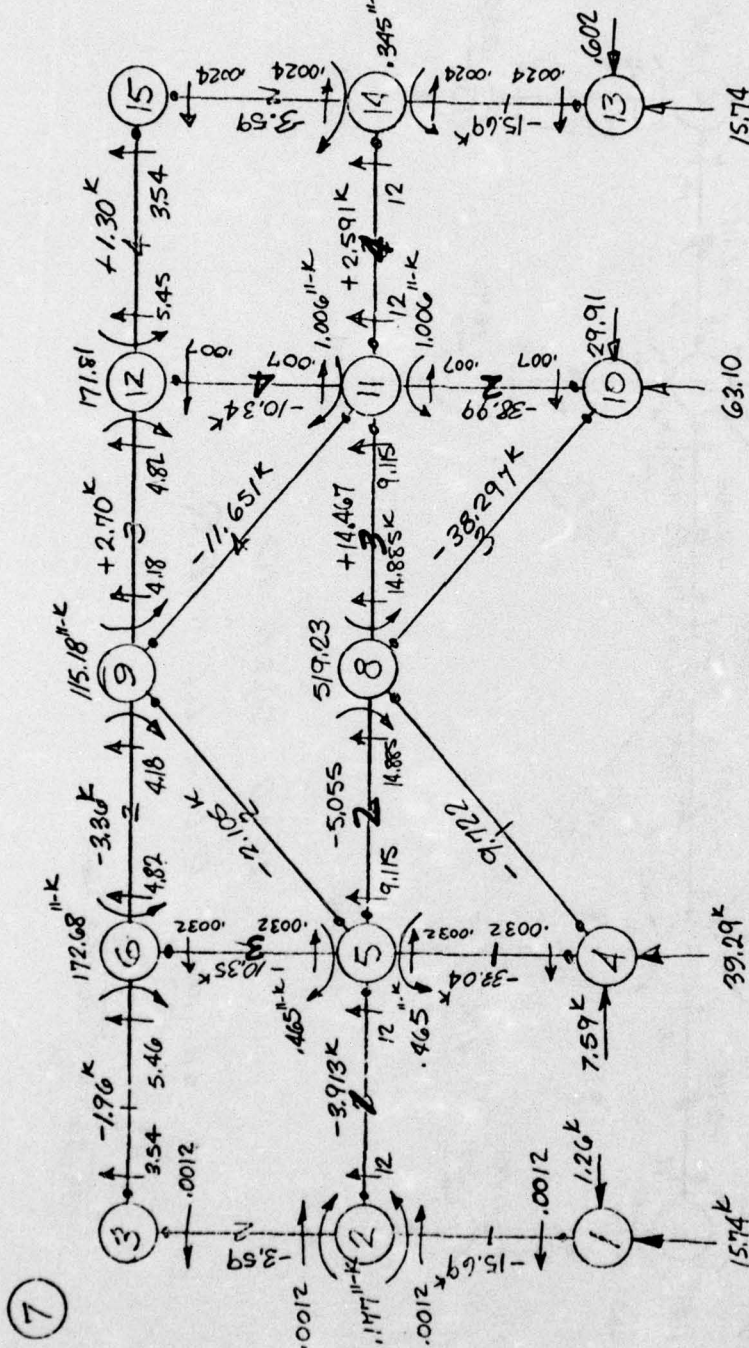
CHECKED BY _____

SHEET NO. ___ OF ___ SHEETS

DATE _____ 19 ____

FILE _____

REF. DRWG. NO. _____



LOAD CASE 6

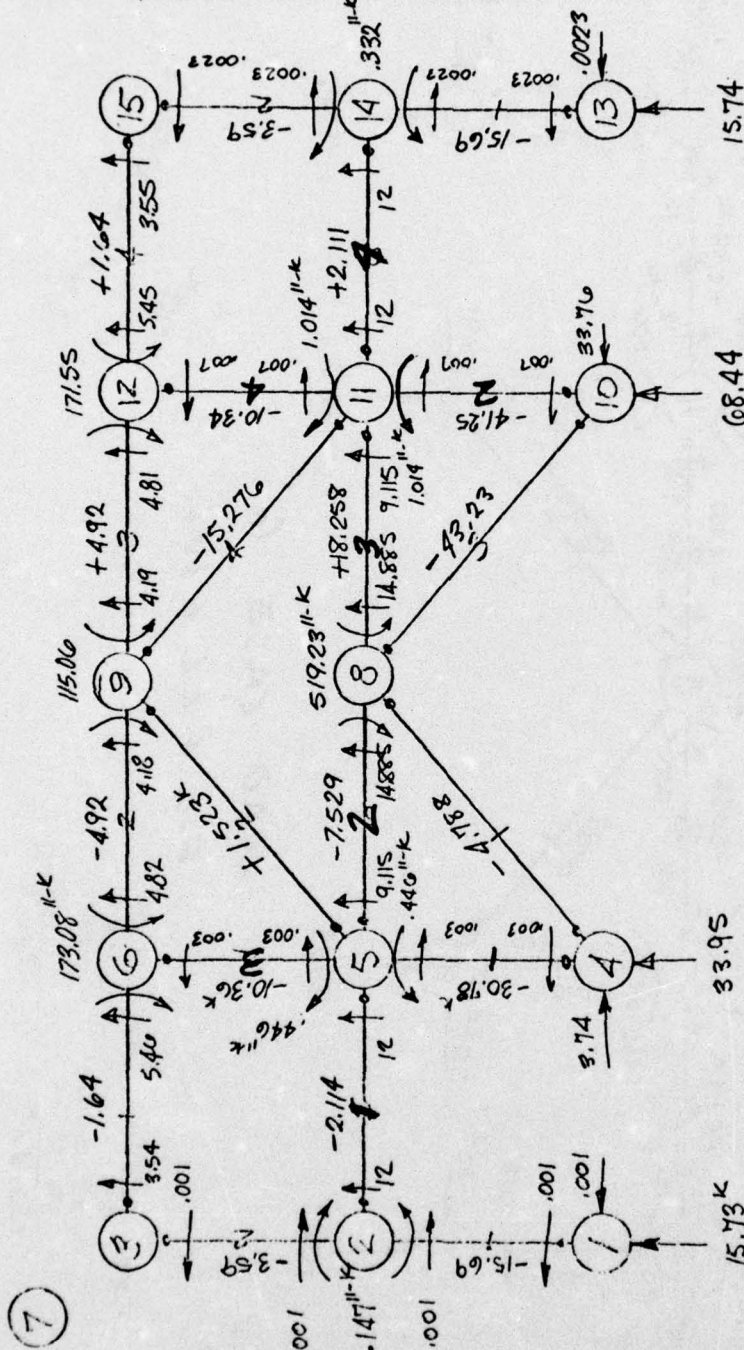
D.L. + L.L. + W.L.

Σ V = 15.74
Σ H = 1.26
Σ M = 39.29
Σ P = 63.10
Σ Q = 15.74
Σ R = 133.87 K

23.03
23.03 = (9.12)(6.0)

CHECKED BY

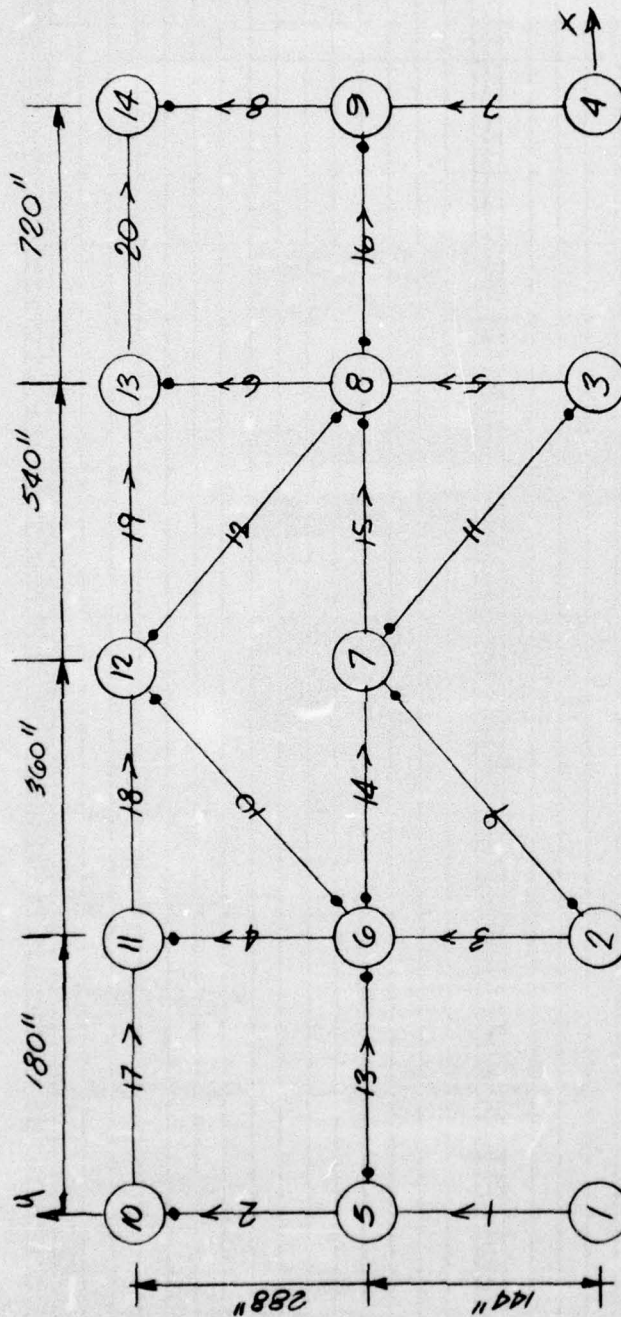
REF. DRWG. NO. _____



LOAD CASE = 10
D.L. + L.L. + E.Q.

$\Sigma V = 15.73$ $\Sigma H = .001$
 33.95 -3.740
 68.44 33.76
 15.74 $\underline{.002}$
 $\underline{133.86}$ 30.023

SHEET NO. _____ OF _____ SHEETS
DATE _____, 19____
FILE _____
REF. DRWG. NO. _____



COMPUTER MODEL SAMPLE PROGRAM
2-STORY, 2-D FRAME

ALL UNITS ARE
KIPS AND INCHES.

20 ELEMENTS
14 NODES
1 MATERIAL
4 GEOMETRIC PROPERTY CARDS.
1 ELASTIC SUPPORT CARD
2 F.E.F CARDS

PROGRAM WILSON 2-D									
REQUESTED BY REVNOLOS									
DATE 23 AUG 75									
PAGE 1 OF 2									
CHECKED BY									
PREPARED BY									
1	2	3	4	5	6	7	8	9	10
A WILSON 2-D SAMPLE PROBLEM 2-STORY 2-D FRAME									
B 1	3000.00		0.27		4	1	2		
C 1	1.0+10		1.0+10						
E 1	2.39		1.195		4.29				
F 1	3.49		1.745		13.20				
G 1	2.65		1.413		98.80				
H 1	6.47		2.690		156.00				
I 1	0.00		4.500		135.00		0.00	4.50	-135.00
J 2	0.00		12.000		360.00		0.00	12.00	-360.00
K 1					0.00		0.00		
L 2					180.00		0.00		
M 3					540.00		0.00		
N 4					720.00		0.00		
O 5					0.00		144.00	2.12	
P 6					180.00		144.00	4.23	
Q 8					540.00		144.00	4.23	
R 10					720.00		144.00	2.12	
S 11					0.00		288.00	1.64	
T 13					180.00		288.00	3.28	
U 14					540.00		288.00	3.28	
V 14					720.00		288.00	1.64	
W 1	5								
X 2	10								
Y 3	6								
Z 4	11								
AA 5	8								
AB 6	13								
AC 7	4								
AD 8	9								

[illegible]

AN30 43 OUTPUT . 11 SEP 75 . 14.43 8039 43

[illegible][illegible]

XXXXXXXXXXXX

.....

XXXXXXXXXXXX

[illegible][illegible]

0039 43 , CORE , 11 SEP 75 , 14.07 0039 43

RETURN TO
SAC TO
C OF E
ADP
A/C/CP/EN

```

14.18.41.1 A7ICE00 1 75/09/11 7600 BKV158 1 A713170 NORM 803943 REYNOLDS
14.18.41.1 INPUT 66008 14.15.57. 11 SEP 75 VIA COKE
14.18.41.1 A713170.P3.1100.CMR5000.803943.REYNOLDS
14.18.41.1 COMMENT. .ID=.....
14.18.41.1 COMMENT. ( RETURN TO
14.18.41.1 COMMENT. ( SACTO
14.18.41.1 COMMENT. ( C OF E
14.18.41.1 COMMENT. ( ADP
14.18.41.1 COMMENT. ( ANDERSEN
14.18.41.1 COMMENT. *PSS,NOTAPES
14.18.41.1 FETCHPS,STRUT,KC1708,KC1708.
14.18.42.1 TAPEPAC DISK 1
14.42.51.1 STAGING COMPLETE 14.42.23. 2 CUS.
14.42.51.1 KC1708 2962 WORDS STORED IN CACHE,
14.42.52.1 LINK,FKC1712,CS=ZERO,LO=0,X.
14.42.54.1 DECMAP DISK 1
14.42.54.1 LOAD COMPLETE, LINK 73.
14.42.54.1 TIME= 24 MSEC.
14.42.54.1 MEMORY LOAD 25000, EXECUTE 44000.
14.42.54.1 FLS=049K FLL=0000K LCM BUFFERS=0034K TOTAL LCM=0100K
14.42.54.1 OUTPUT DISK 1
14.42.54.1 TAPE1 DISK 1
14.42.54.1 TAPE2 DISK 1
14.42.54.1 EXIT
14.42.54.1 DISK USED 360 SECTORS
14.42.54.1 LCM BLD. 17
14.42.54.1 ITC 2.141
14.42.54.1 CPU TIME 0.133 SECONDS.
14.42.54.1 STAGING 2 CUS.
14.42.54.1 75/09/11. 14 CUS.
14.42.54.1 3 1.680 EST.
14.43.20.1 A7ICE00. OUTPUT QUEUED PR 20

```

713-002 2-D FRAME ANALYSIS = V.12/70. RUN = 11 SEP 75 PAGE 1

14,42,54

ILSON 2-D SAMPLE PROBLEM 2-STORY BLDG 2-D FRAME

NUMBER OF ELEMENTS	=	20
NUMBER OF NODAL POINTS	=	14
NUMBER OF MATERIALS	=	1
NUMBER OF ELEMENT TYPES	=	4
NUMBER OF ELASTIC SUPPORT TYPES	=	1
NUMBER OF FIXED END FORCE TYPES	=	2

713-002 2-D FRAME ANALYSIS = V.12/70. RUN = 11 SEP 75 PAGE 2

MATERIAL	YOUNG S MODULUS	POISSON S RATIO
1	30000.	.27000

713-002 2-D FRAME ANALYSIS = V.12/70. RUN = 11 SEP 75 PAGE 3

SPRING CONSTANTS OF ELASTIC SUPPORTS

TYPE	LINEAR STIFFNESS	X	LINEAR STIFFNESS	Y	ROTATIONAL STIFFNESS	Z
1	10000000000.000		10000000000.000			.0

713-002 2-D FRAME ANALYSIS - V.12/70. RUN - 11 SEP 75 PAGE 4

ELEMENT TYPE	AXIAL AREA	SHEAR AREA	MOMENT OF INERTIA
1	2,390	1,195	4,290
2	3,490	1,745	13,200
3	2,650	1,413	35,800
4	6,470	2,690	156,000

713-002 2-D FRAME ANALYSIS - V.12/70. RUN - 11 SEP 75 PAGE 5

FIXED END FORCES IN LOCAL COORDINATES

TYPE	AXIAL I	SHEAR I	MOMENT I	AXIAL J	SHEAR J	MOMENT J
1	0	4,500	135,000	0	4,500	-135,000
2	0	12,000	360,000	0	12,000	-360,000

NODAL COORDINATES			BOUNDARY CONDITIONS			ELASTIC SUPPORT	
NODE CODE	X	Y	X	Y	Z		TYPE
1	0	0	0	0	0	0	1
2	180.000	0	0	0	0	0	1
3	540.000	0	0	0	0	0	1
4	720.000	0	0	0	0	0	1
5	0	144.000	2.120	0	0	0	0
6	180.000	144.000	4.230	0	0	0	0
7	360.000	144.000	4.230	0	0	0	0
8	540.000	144.000	4.230	0	0	0	0
9	720.000	144.000	2.120	0	0	0	0
10	0	288.000	1.640	0	0	0	0
11	180.000	288.000	3.280	0	0	0	0
12	360.000	288.000	3.280	0	0	0	0
13	540.000	288.000	3.280	0	0	0	0
14	720.000	288.000	1.640	0	0	0	0

713-002 2ND FRAME ANALYSIS - V.12/70. RUN - 11 SEP 75 PAGE 7

ELEMENT	NODE	MATERIAL	ELEMENT	ELEMENT	FIXED	END	RELATIVE	STIFFNESS	CARRY
I	J	TYPE	TYPE	CODE	FORCE	TYPE	KIJ	KJI	OVER
1	1	5	1	-0	-0	-0	4.00000	4.00000	.50000
2	3	10	1	1	1	-0	4.00000	4.00000	.50000
3	2	6	1	-0	-0	-0	4.00000	4.00000	.50000
4	6	11	1	1	1	-0	4.00000	4.00000	.50000
5	3	8	1	-0	-0	-0	4.00000	4.00000	.50000
6	8	13	1	1	1	-0	4.00000	4.00000	.50000
7	4	9	1	-0	-0	-0	4.00000	4.00000	.50000
8	9	14	1	1	1	-0	4.00000	4.00000	.50000
9	2	7	1	1001	1001	-0	4.00000	4.00000	.50000
10	6	12	1	1001	1001	-0	4.00000	4.00000	.50000
11	3	7	1	1001	1001	-0	4.00000	4.00000	.50000
12	8	12	1	1001	1001	-0	4.00000	4.00000	.50000
13	5	6	1	1001	1001	2	4.00000	4.00000	.50000
14	6	7	1	1000	1000	2	4.00000	4.00000	.50000
15	7	8	1	1	1	2	4.00000	4.00000	.50000
16	8	9	1	1001	1001	2	4.00000	4.00000	.50000
17	10	11	1	-0	-0	1	4.00000	4.00000	.50000
18	11	12	1	-0	-0	1	4.00000	4.00000	.50000
19	12	13	1	-0	-0	1	4.00000	4.00000	.50000
20	13	14	1	-0	-0	1	4.00000	4.00000	.50000

713-002 2-D FRAME ANALYSIS - V.12/70. RUN - 11 SEP 75 PAGE 8

JOINT	X-DISPLACEMENT	Y-DISPLACEMENT	Z-ROTATION
1	.00000	.00000	.00047
2	.00000	.00000	.00045
3	.00000	.00000	.00055
4	.00000	.00000	.00057
5	.06332	.03120	.00038
6	.06135	.04172	.00037
7	.05423	.08393	.00004
8	.07103	.05615	.00037
9	.07299	.03122	.00038
10	.11054	.03831	.00613
11	.10682	.05587	.00135
12	.09567	.07857	.00006
13	.10683	.07028	.00135
14	.11055	.03834	.00625

713-002 2-D FRAME ANALYSIS - V.12/70. RUN - 11 SEP 75 PAGE 9

NODE	ELASTIC FOUNDATION REACTIONS		
	FORCE X	FORCE Y	MOMENT Z
1	.0001	15.537	0
2	3.574	33.199	0
3	-33.521	67.718	0
4	.0002	15.546	0

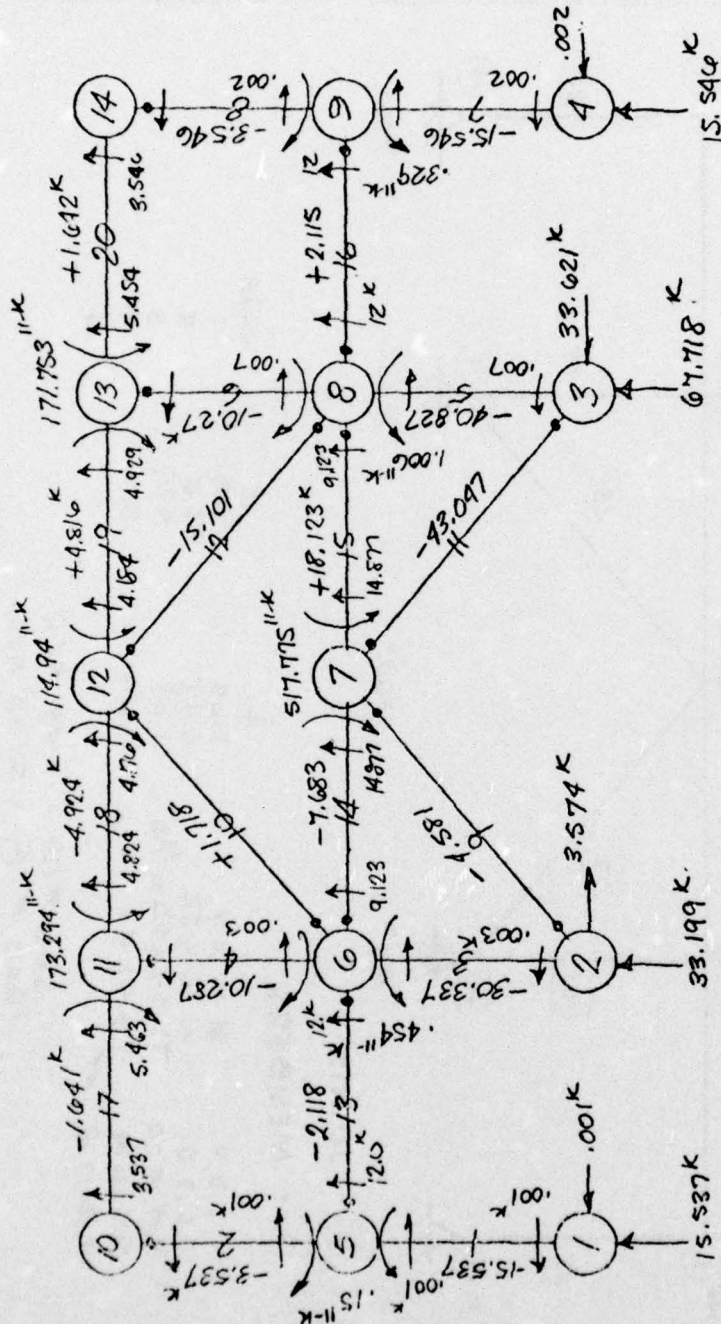
ELEMENT	MEMBER END FORCES					
	AXIAL I	SHEAR I	MOMENT I	AXIAL J	SHEAR J	MOMENT J
1	15.537	.001	.000	-15.537	-.001	.150
2	3.537	-.001	-.150	-3.537	.001	0
3	30.337	.003	.000	-30.337	-.003	.450
4	10.287	-.003	-.450	-10.287	.003	0
5	40.827	.007	0	-40.827	-.007	1.006
6	10.270	-.007	-1.006	-10.270	.007	0
7	15.546	.002	.000	-15.546	-.002	.329
8	3.546	-.002	-.329	-3.546	.002	0
9	4.581	.000	0	-4.581	-.000	0
10	-1.718	.000	0	1.718	-.000	0
11	43.047	-.000	0	-43.047	.000	0
12	15.101	-.000	0	-15.101	.000	0
13	2.118	12.000	0	-2.118	12.000	0
14	7.683	9.123	0	-7.683	10.877	-517.775
15	-15.123	14.877	517.775	15.123	9.123	0
16	-2.115	12.000	0	2.115	12.000	0
17	1.641	3.537	.000	-1.641	5.463	-173.294
18	4.924	4.824	173.294	-4.924	4.176	-114.940
19	-4.929	4.164	114.940	4.929	4.816	-171.753
20	-1.642	5.454	171.753	1.642	3.546	-.000

NODE	APPLIED JOINT LOADS AND REACTIONS		
	FORCE X	FORCE Y	MOMENT Z
1	.000	.000	-.000
2	-.000	.000	.000
3	-.000	.000	0
4	-.000	.000	.000
5	2.120	-.000	.000
6	4.230	.000	.000
7	4.230	.000	0
8	4.230	-.000	.000
9	2.120	-.000	0
10	1.640	.000	.000
11	3.280	.000	.000
12	3.280	0	0
13	3.280	-.000	0
14	1.640	0	-.000

PROBLEMS COMPLETED OR CONTROL CARD ERROR

PROJECT _____
 ITEM WILSON 2-D FRAME
 COMPUTED BY DWR CHECKED BY _____

SHEET NO. _____ OF _____ SHEETS
 DATE _____ 19____
 FILE _____
 REF. DRWG. NO. _____

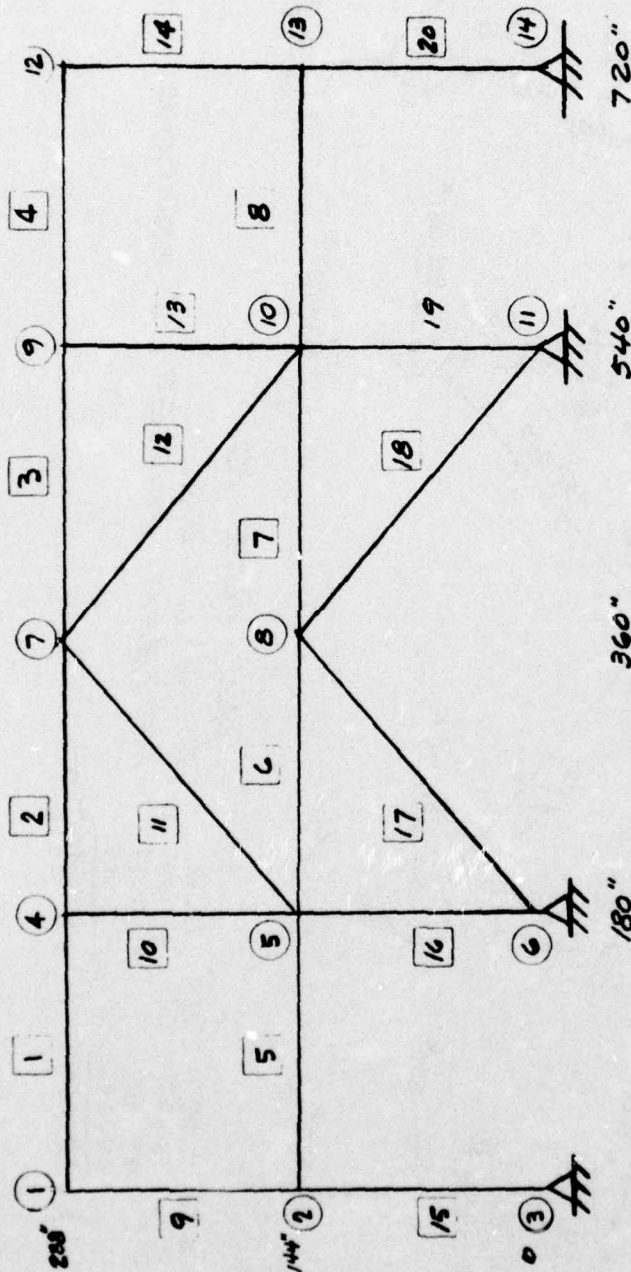


LOAD CASE 10
 D.L. + L.L. + EQ.
 MEMBER FORCES & REACTIONS

ΣV = 15.537 ΣH = 33.621
 33.199 - .001
 67.718 - 3.574
 15.546 - .002
 ↑ 132.000 30.040 K ←

PROJECT 2-D FRAME SAMPLE PROBLEM
 ITEM SAGS
NORTH CENTRAL DIVISION
 COMPUTED BY SOUPOS CHECKED BY _____

SHEET NO. ____ OF ____ SHEETS
 DATE _____ 19 ____
 FILE _____
 REF. DRWG. NO. _____



NODE
 1 2 3 4 4

I
 38.8
 156.0
 4.29
 13.2

A
 2.65
 6.47
 2.39
 3.49

① - JOINTS

① - MEMBERS

1, 2, 3, 4
 5, 6, 7, 8
 9, 14, 15, 20
 10, 13, 16, 19
 11, 12, 17, 18

M 10 x 9
 W 12 x 22
 TS 3 1/2 x 3 1/2 x 3/16
 TS 5 x 5 x 3/16

600 #/ft. = 0.05 K/in.
 1600 #/ft. = 0.133 K/in.

100	2-D FRAME SAMPLE PROBLEM
110	3.0, 2.0, 1
120	14.20
130	1.4, 4
140	1.29E6, 11.5E5
150	1.2, 65, 38.3
160	2.6, 47, 15.5
170	3.2, 39, 0.29
180	4.3, 49, 13.2
190	3, "SOCKET"
200	6, "SOCKET"
210	11, "SOCKET"
220	14, "SOCKET"
230	1.0, 28
240	2.0, 14
250	3.0, 0
260	4, 180, 230
270	5, 180, 140
280	6, 180, 0
290	7, 350, 290
300	8, 350, 140
310	9, 540, 290
320	10, 540, 140
330	11, 540, 0
340	12, 720, 283
350	13, 720, 140
360	14, 720, 0
370	1, 1.4, 1.1
380	2, 4.7, 1.1
390	3, 7.9, 1.1
400	4, 9.12, 1.1
410	5, 2.3, 1.2
420	6, 5.8, 1.2
430	7, 8.10, 1.2
440	8, 10.13, 1.2
450	9, 1.2, 1.3
460	10, 4.5, 1.4
470	11, 7.5, 1.4
480	12, 7.10, 1.4
490	13, 9.10, 1.4
500	14, 12.13, 1.3
510	15, 2.3, 1.3
520	16, 5.6, 1.4
530	17, 4.6, 1.4
540	18, 3.1, 1.4
550	19, 10.1, 1.4
560	20, 13.14, 1.3
570	0, "0L 0R 1.1"
580	4
590	1.2, -.025
600	2.2, -.025
610	3.2, -.025
620	4.2, -.025
630	5.2, -.067
640	6.2, -.067
650	7.2, -.067
660	8.2, -.067
670	10, "4L"

ALL UNITS ARE
INCH/KIPS.

ALL LOADINGS CAN BE
COMPUTED WITHOUT RE-ENTERING
THE INPUT DATA.

680	1.1.1.96
690	4.1.1.4
700	7.1.1.0
710	9.1.1.4
720	12.1.1.3
730	2.1.3.92
740	5.1.2.79
750	8.1.2.79
760	10.1.2.71
770	13.1.2.6
780	0
790	10."EQ"
800	1.1.1.54
810	4.1.3.28
820	7.1.3.28
830	9.1.3.28
840	12.1.1.64
850	2.1.2.12
860	5.1.4.23
870	8.1.4.23
880	10.1.4.23
890	13.1.2.12
900	0
910	10."OL + LL + EQ"
920	1.1.1.54
930	4.1.3.28
940	7.1.3.28
950	9.1.3.28
960	12.1.1.54
970	2.1.2.12
980	5.1.4.23
990	8.1.4.23
1000	10.1.4.23
1010	13.1.2.12
1020	0
1030	1.2.-.05
1040	2.2.-.05
1050	3.2.-.05
1060	4.2.-.05
1070	5.2.-.133
1080	6.2.-.133
1090	7.2.-.133
1100	8.2.-.133
*QUIT	
SCALE:1.0	
!SAGS	
VERSION 11-1-72	

ENTER DATA FILE NAME? SACU

PRINT INPUT DATA? YES

S A G S

STATIC ANALYSIS OF GENERAL STRUCTURES

STRUCTURAL DYNAMICS RESEARCH CORPORATION

2-D FRAME SAMPLE PROBLEM

1 - PLANAR FRAME ANALYSIS ***

SPAN	LENGTH	FORE END	AFT END	MATERIAL	SECTION	ROTATION	TEMP.
		JOINT	JOINT	CODE	CODE	ANGLE	
1	180.00	1	4	1	1		
2	180.00	4	7	1	1		
3	180.00	7	9	1	1		
4	180.00	9	12	1	1		
5	180.00	2	5	1	2		
6	180.00	5	8	1	2		
7	180.00	8	10	1	2		
8	180.00	10	13	1	2		
9	144.00	1	2	1	3		
10	144.00	4	5	1	4		
11	230.51	7	5	1	4		
12	230.51	7	10	1	4		
13	144.00	9	10	1	4		
14	144.00	12	13	1	3		
15	144.00	2	3	1	3		
16	144.00	5	6	1	4		
17	230.51	8	6	1	4		
18	230.51	8	11	1	4		
19	144.00	10	11	1	4		
20	144.00	13	14	1	3		

JOINT COORDINATES			
JOINT	X	Y	Z
1	0.	288.000	
2	0.	144.000	
3	0.	0.	
4	180.000	288.000	
5	180.000	144.000	
6	180.000	0.	
7	360.000	288.000	
8	360.000	144.000	
9	360.000	0.	
10	540.000	144.000	
11	540.000	0.	
12	720.000	288.000	
13	720.000	144.000	
14	720.000	0.	

MATERIAL PROPERTIES			
CODE	E	G	DENSITY THERMAL COEFFICIENT
1	29.0E+06	11.5E+06	

COPY AVAILABLE TO DDC DOES NOT
PERMIT FULLY LEGIBLE PRODUCTION

STATIC ANALYSIS OF GENERAL STRUCTURES
2-D FRAME SAMPLE PROBLEM

CROSS-SECTION PROPERTIES
MOMENT OF SHEAR

CODE	AREA	INERTIA	RATIO
1	2.65E+00	3.85E+01	0.
2	5.17E+00	1.55E+02	0.
3	2.59E+00	4.29E+00	0.
4	5.40E+00	1.32E+01	0.

DISTANCE TO OUTER FIBER

CODE	Y	Z	R
1	1.000	1.000	1.000
2	1.000	1.000	1.000
3	1.000	1.000	1.000
4	1.000	1.000	1.000

SPECIFIED RESTRAINTS
JOINT DIR TYPE VALUE

3		SOCKET	
5		SOCKET	
11		SOCKET	
14		SOCKET	

LOADING ID. 1: DL OR L

DISTRIBUTED LOADING
SPAN DIR COORDINATE VALUE

1	Y	ABSOLUTE	-2.50E-02
2	Y	ABSOLUTE	-2.50E-02
3	Y	ABSOLUTE	-2.50E-02
4	Y	ABSOLUTE	-2.50E-02
5	Y	ABSOLUTE	-6.70E-02
6	Y	ABSOLUTE	-6.70E-02
7	Y	ABSOLUTE	-6.70E-02
8	Y	ABSOLUTE	-6.70E-02

COPY AVAILABLE TO DDC DOES NOT
PERMIT FULLY LEGIBLE PRODUCTION

STATIC ANALYSIS OF GENERAL STRUCTURES
2-D FRAME SAMPLE PROBLEM

LOADING NO. 2: WL

APPLIED FORCES			
JOINT	DIR	TYPE	VALUE
1	X	FORCE	1.95E+00
4	X	FORCE	1.40E+00
7	X	FORCE	1.40E+00
9	X	FORCE	1.40E+00
12	X	FORCE	1.30E+00
2	X	FORCE	2.79E+00
5	X	FORCE	2.79E+00
8	X	FORCE	2.79E+00
10	X	FORCE	2.79E+00
13	X	FORCE	2.60E+00

LOADING NO. 3: EQ

APPLIED FORCES			
JOINT	DIR	TYPE	VALUE
1	X	FORCE	1.64E+00
4	X	FORCE	3.29E+00
7	X	FORCE	3.29E+00
9	X	FORCE	3.29E+00
12	X	FORCE	1.64E+00
2	X	FORCE	2.12E+00
5	X	FORCE	4.23E+00
8	X	FORCE	4.23E+00
10	X	FORCE	4.23E+00
13	X	FORCE	2.12E+00

LOADING NO. 4: DL 4.1 4.1E9

APPLIED FORCES

JOINT	DIR	TYPE	VALUE
1	X	FORCE	1.64E+00
4	X	FORCE	5.23E+00
7	X	FORCE	5.23E+00
9	X	FORCE	5.23E+00

12	X	FORCE	1.64E+00
2	X	FORCE	2.12E+00
5	X	FORCE	4.23E+00
8	X	FORCE	4.23E+00
10	X	FORCE	4.23E+00
13	X	FORCE	2.12E+00

PAGE 4

STATIC ANALYSIS OF GENERAL STRUCTURES
2-D FRAME SAMPLE PROBLEM

DISTRIBUTED LOADING

SPAN	DIR	COORDINATE	VALUE
1	Y	ABSOLUTE	-5.00E-02
2	Y	ABSOLUTE	-5.00E-02
3	Y	ABSOLUTE	-5.00E-02
4	Y	ABSOLUTE	-5.00E-02
5	Y	ABSOLUTE	-1.33E-01
6	Y	ABSOLUTE	-1.33E-01
7	Y	ABSOLUTE	-1.33E-01
8	Y	ABSOLUTE	-1.33E-01

NO. OF EQUATIONS = 34 BANDWIDTH = 12

SIZE FACTOR = 342

RUN PROGRAM SAG1

SROUS:37.8

TSAG1

VERSION 11-1-72

ENTER DATA FILE NAME? SAG1

ENTER OUTPUT FILE NAME? NONE

IN BEAM

IN SETUP

IN DCPHO

DIAGONAL ELEMENTS: AVERAGE = 3.203+007

SMALLEST = 1.279+015 ROW 28

S A G S

STATIC ANALYSIS OF GENERAL STRUCTURES

STRUCTURAL DYNAMICS RESEARCH CORPORATION

2-D FRAME SAMPLE PROBLEM

*** LOADING NO. 1: DL OR LL

JOINT DISPLACEMENTS

JOINT	X	Y	ROTATION
1	5.554-007	-1.772-005	-2.539-006
2	2.721-006	-1.339-005	-1.964-006
3	0.	0.	1.008-006
4	1.775-007	-3.439-005	3.035-007
5	-2.600-006	-2.948-005	3.441-007
6	0.	0.	-1.539-007
7	-1.016-022	-4.518-005	2.585-026
8	-1.234-024	-3.333-005	5.325-025
9	-1.775-007	-3.560-005	-3.985-007
10	2.600-006	-2.948-005	-3.441-007
11	0.	0.	1.539-007
12	-5.554-007	-1.772-005	2.589-006
13	2.721-006	-1.339-005	1.964-006
14	0.	0.	-1.008-006

COPY AVAILABLE TO DDC DOES NOT
PERMIT FULLY LEGIBLE PRODUCTION 120

JOINT REACTIONS

JOINT (X) (Y) (Z)

3 3.59+000 2.643+001 0.
6 7.119+000 2.643+001 0.
1 7.119+000 2.643+001 0.
14 -3.565-002 6.083+000 0.

JOINT FORCES

AXIAL SHEAR MOMENT

JO.

AXIAL

SHEAR

MOMENT

SPAN	JO.	AXIAL	SHEAR	MOMENT	JO.	AXIAL	SHEAR	MOMENT
1	1	1.62-001	1.84+00	1.22+001	4	-1.62-001	2.67+00	-9.55+001
2	4	7.98-002	2.35+00	7.91+001	7	-7.98-002	2.13+000	-3.09+001
3	7	7.58-002	2.15+00	6.09+001	9	-7.58-002	2.35+000	-7.91+001
4	9	1.62-001	2.35+00	8.57+001	12	-1.62-001	1.84+00	-1.22+001
5	2	-1.26-001	4.84+000	1.62+001	5	1.26-001	7.22+000	-2.30+002
6	5	-2.71+000	5.71+00	1.61+002	10	2.71+000	6.35+001	-2.13+002
7	8	-1.26-001	7.22+00	2.30+002	13	1.26-001	0.84+000	-1.52+001
8	10	1.34+000	-1.62-001	-1.22+001	2	-1.34+000	1.62-001	-1.11+001
9	1	5.01+000	4.59-002	6.34+001	5	-5.01+000	3.59-002	6.09+001
10	4	5.41+001	2.07-002	1.74+000	5	-5.41+000	-2.17-002	2.83+000
11	7	5.41+001	-2.07-002	-1.74+000	10	-5.41+000	2.07-002	-2.83+000
12	9	5.01+000	-4.59-002	-6.34+001	13	-5.01+000	8.60-002	-6.09+001
13	2	-5.01+000	4.59-002	-6.34+001	13	-5.01+000	-1.62-001	1.11+001
14	5	-5.41+001	2.07-002	1.74+000	5	-5.41+000	3.57+001	-1.59+001
15	7	-5.41+001	-2.07-002	-1.74+000	10	5.41+000	-1.70-002	-1.02+001
16	9	-5.01+000	-4.59-002	-6.34+001	13	-5.01+000	-3.10-003	6.15-001
17	2	-5.01+000	4.59-002	-6.34+001	13	-5.01+000	-3.10-003	6.15-001

STATIC ANALYSIS OF GIRDER STRUCTURES
2-D FRAME SAMPLE PROBLEM

SPAN	JT.	FORCES			AFF. END FORCES		
		AXIAL	SHEAR	MOMENT	JT. AXIAL	SHEAR	MOMENT
18	3	9.14+0	3.10-0.3	6.13-0.3	1	9.14+0.3	1.02-0.1
19	10	2.07+0.1	-1.70-0.2	-2.5+0.0	11	-2.07+0.1	1.70-0.02
20	13	6.59+0	3.57-0.02	5.14+0.1	14	-5.59+0.02	-3.57-0.02
							3.47-0.13

STRESS CALCULATIONS

SPAN	END	AXIAL	MY/SI	P/A	SHEAR
1	AFT	-2.203+0.1	0.	-5.103-0.2	0.
2	FOR	2.033+0	0.	-2.859-0.02	0.
3	AFT	-2.033+0.1	0.	-2.859-0.02	0.
4	FOR	2.203+0.1	0.	-6.106-0.2	0.
5	AFT	-1.471+0.1	0.	1.250-0.2	0.
6	FOR	1.393+0.0	0.	4.190-0.01	0.
7	AFT	-1.393+0	0.	4.190-0.01	0.
8	FOR	1.471+0.1	0.	1.250-0.2	0.
9	AFT	-2.842+0.1	0.	-7.711-0.01	0.
10	FOR	4.803-0.1	0.	-1.435+0.02	0.
11	AFT	2.142-0.1	0.	-1.733-0.01	0.
12	AFT	-2.142-0.1	0.	-9.783-0.01	0.
13	FOR	4.803-0.1	0.	-1.435+0.02	0.
14	FOR	2.842+0.1	0.	-7.711-0.01	0.
15	FOR	1.197+0.1	0.	-2.798+0.0	0.
16	FOR	1.920-0.01	0.	-5.937+0.03	0.
17	FOR	4.641-0.02	0.	-2.619+0.01	0.
18	FOR	-4.641-0.02	0.	-2.619+0.01	0.
19	FOR	-1.920-0.01	0.	-5.937+0.03	0.
20	FOR	1.197+0.02	0.	-2.798+0.0	0.

COPY AVAILABLE TO DDC DOES NOT
PERMIT FULLY LEGIBLE PRODUCTION

STATIC ANALYSIS OF GENERAL STRUCTURES
2-D FRAME SAMPLE PROBLEM

LOADING NO. 2: WL

JOINT	JOINT DISPLACEMENTS		ROTATION
	X	Y	
1	8.034-005	1.421-007	1.103-008
2	5.533-005	1.126-007	2.803-008
3	0.	0.	-5.902-007
4	7.572-005	4.111-006	-3.591-008
5	5.158-005	4.124-006	-3.231-008
6	0.	0.	-3.921-007
7	6.802-005	7.801-007	-2.743-008
8	4.161-005	1.237-009	1.594-008
9	7.424-005	-4.107-006	-4.145-008
10	5.032-005	-4.124-006	-3.211-008
11	0.	0.	-3.741-007
12	7.725-005	1.422-007	1.495-008
13	5.242-005	-1.124-007	2.855-008
14	0.	0.	-5.641-007

JOINT	JOINT REACTIONS		MOMENT
	FX	FY	
3	-7.419-003	-5.411-002	0.
6	-1.117+001	-1.182+001	0.
11	1.117+001	1.132+001	0.
14	-7.112-003	5.412-002	0.

SPAN JOINT				AFF END JOINT			
SPAN	JOINT	AXIAL	SHEAR	MOMENT	JOINT	AXIAL	SHEAR
1	1	1.95+00	-1.42-002	-9.84-001	4	-1.95+000	1.42-002
2	4	3.32+01	-5.44-003	-5.43-001	7	-3.32+000	5.44-003
3	7	-2.63+000	-3.01-003	-1.83-001	9	2.63+000	3.01-003
4	9	-1.29+000	-1.47-002	-1.67+000	12	1.29+000	1.47-002
5	2	3.93+00	-4.00-002	-2.03+00	5	-3.93+000	4.00-002
6	5	1.00+001	-2.00-003	-5.91-001	8	-1.00+001	2.00-003
7	8	-9.09+000	-1.84-003	2.41-001	10	9.09+000	1.84-003
8	10	-2.61+00	-3.04-002	-5.07+00	13	2.61+000	3.04-002
9	1	-1.42-002	1.34-002	9.84-001	2	1.42-002	-1.34-002
10	4	8.76-003	2.95-002	2.11+000	5	-8.76-003	-2.95-002
11	7	-4.72+000	2.29-003	2.65-001	5	4.72+000	-2.24-003
12	7	4.72+000	3.00-003	3.53-001	10	-4.72+000	-3.00-003
13	9	-1.17-002	2.45-002	2.03+000	10	1.17-002	-2.45-002
14	12	1.47-002	1.37-002	9.75-001	13	-1.47-002	-1.37-002
15	2	-5.42-002	7.92-003	1.07+00	3	5.42-002	-7.92-003
16	5	-2.90+000	3.43-002	3.31+000	6	2.90+000	-3.43-002
17	8	-1.43+001	-7.44-003	-2.50-001	6	1.43+001	7.44-003
18	10	1.43+001	7.44-003	2.50-001	10	-1.43+001	-7.44-003
19	10	2.90+000	3.22-002	3.23+000	11	-2.90+000	-3.22-002
20	13	5.41-002	7.11-003	1.32+000	14	-5.41-002	-7.11-003

COPY AVAILABLE TO DDC DOES NOT
 PERMIT FULLY LEGIBLE PRODUCTION

COPY AVAILABLE TO DDC DOES NOT
PERMIT FULLY LEGIBLE PRODUCTION

STATIC ANALYSIS OF GENERAL STRUCTURES
2-1 FRAME SAMPLE PROBLEM

STRESS CALCULATIONS				P/A	SHEAR
SPAN	END	WZ/S	WZ/S		
1	AFT	-4.051-0.2	0.	-7.34-0.1	0.
2	FORE	-1.390-0.02	0.	-1.252+0.00	0.
3	AFT	-9.228-0.13	0.	1.003+0.01	0.
4	FORE	-4.301-0.02	0.	4.454-0.01	0.
5	AFT	-3.241-0.02	0.	-5.049-0.01	0.
6	FORE	-3.791-0.03	0.	-1.607+0.00	0.
7	AFT	3.66-0.3	0.	1.401+0.00	0.
8	FORE	-3.252-0.02	0.	4.024-0.01	0.
9	AFT	2.352-0.1	0.	5.040-0.13	0.
10	AFT	1.617-0.01	0.	-2.510-0.03	0.
11	FORE	2.016-0.03	0.	1.352+0.01	0.
12	FORE	2.674-0.02	0.	-1.353+0.00	0.
13	AFT	1.573-0.1	0.	3.147-0.03	0.
14	AFT	2.311-0.01	0.	-6.145-0.03	0.
15	FORE	2.490-0.1	0.	2.268-0.02	0.
16	FORE	2.519-0.01	0.	8.305-0.01	0.
17	AFT	-1.110-0.01	0.	4.047+0.01	0.
18	AFT	-1.070-0.1	0.	-4.045+0.01	0.
19	FORE	2.447-0.1	0.	-1.305-0.01	0.
20	FORE	2.337-0.01	0.	-2.264-0.02	0.

2-1 FIVE SAMPLES

JOINT	X	Y	ROTATION
1	1.134-004	2.352-007	2.201-018
2	7.955-015	1.829-017	3.057-013
3	0.	0.	-7.574-017
4	1.095-014	7.234-015	-5.770-013
5	6.325-005	7.259-015	-4.371-018
6	0.	0.	-5.051-017
7	9.850-015	-7.613-025	-4.976-018
8	5.991-015	0.	3.240-018
9	1.095-014	-7.234-015	-5.670-018
10	0.421-015	7.259-015	-4.371-013
11	0.	0.	-5.051-017
12	1.134-004	-2.352-017	2.201-018
13	7.955-015	-1.829-017	3.057-013
14	0.	0.	-7.574-017

JOINT	JOINT REACTIONS $\bar{F}(i)$	MOMENT $\bar{F}(j)$
3	-9.645-003	-3.402-002
5	-1.502+001	-1.709+001
13	-1.502+001	-1.702+001
14	-9.646-003	8.402-002

COPY AVAILABLE TO DDC DOES NOT
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SPAN		SOURCE			JF			AET		
JF		AXIAL	SHEAR	MOMENT	JF		AXIAL	SHEAR	MOMENT	
1	1	1.62+00	-2.52-002	-1.71+00	4	1	1.62+00	2.52-002	-2.82+00	
2	4	4.85+00	-7.42-003	-7.74-001	7	4	4.85+00	7.42-003	-5.62-001	
3	7	4.85+00	-7.42-003	-5.62-001	9	4	4.85+00	7.42-003	-7.74-001	
4	7	1.62+00	2.52-002	3.42+00	12	1	1.62+00	2.52-002	1.71+00	
5	2	2.13+00	-6.24-002	-3.16+00	5	2	2.13+00	6.24-002	-3.16+00	
6	3	1.22+00	4.27-001	4.53-001	8	1	1.22+00	4.27-001	3.73-001	
7	8	-1.29+00	-4.27-001	3.73-001	10	1	1.29+00	4.27-001	-4.50-001	
8	10	2.13+00	6.24-002	3.16+00	13	2	2.13+00	6.24-002	3.16+00	
9	1	-2.52-002	2.41-002	1.71+00	2	2	2.52-002	-2.41-002	1.76+00	
10	4	1.74-002	5.06-002	3.59+00	5	1	1.74-002	5.06-002	3.59+00	
11	7	4.30+00	4.39-003	5.52-001	5	3	4.30+00	4.39-003	5.55-001	
12	7	4.30+00	4.39-003	5.52-001	10	3	4.30+00	4.39-003	5.55-001	
13	9	-1.74-002	5.06-002	3.59+00	10	1	1.74-002	5.06-002	3.59+00	
14	12	2.52-002	2.41-002	1.71+00	13	2	2.52-002	-2.41-002	1.76+00	
15	2	-3.40-002	2.70-003	1.40+00	3	4	3.40-002	-2.70-003	1.04-001	
16	5	-5.10+00	4.37-002	4.35+00	6	5	5.10+00	4.37-002	1.94+00	
17	8	-1.92+00	-1.00-002	-3.73-001	6	1	1.92+00	1.00-002	-1.94+00	
18	3	1.92+00	-1.00-002	-3.73-001	11	1	1.92+00	1.00-002	-1.94+00	
19	10	5.10+00	4.37-002	4.35+00	11	5	5.10+00	4.37-002	1.94+00	
20	13	4.80-002	2.70-003	1.40+00	14	8	4.80-002	-2.70-003	1.04-001	

COPY AVAILABLE TO DDC DOES NOT
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STATIC ANALYSIS OF GENERAL STRUCTURES
2-D FRAME SAMPLE PROBLEM

STRESS CALCULATIONS

SPIN	END	47/54	47/54	2/A	SHEAR
1	AFT	-7.258-002	0.	-6.098-001	0.
2	FORE	-1.934-002	0.	-1.828+000	0.
3	AFT	-1.934-002	0.	1.828+000	0.
4	FORE	-7.268-002	0.	6.098-001	0.
5	AFT	-5.234-002	0.	3.293-001	0.
6	FORE	-2.834-003	0.	-1.987+000	0.
7	AFT	-2.834-003	0.	1.987+000	0.
8	FORE	-5.238-002	0.	3.293-001	0.
9	AFT	4.103-001	0.	1.053-002	0.
10	AFT	2.795-001	0.	-5.086-003	0.
11	AFT	4.281-002	0.	2.379+000	0.
12	AFT	4.281-002	0.	-2.379+000	0.
13	AFT	2.795-001	0.	5.086-003	0.
14	AFT	4.103-001	0.	-1.053-002	0.
15	FORE	3.255-001	0.	3.583-002	0.
16	FORE	3.297-001	0.	1.462+000	0.
17	AFT	-1.467-001	0.	5.496+000	0.
18	AFT	-1.467-001	0.	-5.496+000	0.
19	FORE	3.297-001	0.	-1.462+000	0.
20	FORE	3.255-001	0.	-3.683-002	0.

STATIC ANALYSIS OF GENERAL STRUCTURES
2-D FRAME SAMPLE PROBLEM

LOADING CO. at JOINTS

JOINT DISPLACEMENTS

JOINT	X	Y	ROTATION
1	1.145-004	-3.506-005	-5.156-005
2	6.483-015	-2.745-015	-3.947-005
3	0.	0.	1.246-006
4	1.100-004	-6.569-005	7.314-007
5	6.308-005	-5.141-005	6.343-007
6	9.830-005	-9.06-005	-4.038-007
7	5.593-005	-6.517-005	-3.240-008
8	1.093-004	-8.015-005	-8.648-007
9	7.308-005	-6.593-005	-7.514-007
10	0.	0.	-1.978-007
11	1.123-004	-3.513-005	9.201-006
12	7.577-005	-2.782-005	3.944-006
13	0.	0.	2.759-006

JOINT REACTIONS

JOINT	F(X)	F(Y)	MOMENT
1	0.110-002	1.521-001	0.
2	-8.512-001	3.548+001	0.
3	-2.915+001	6.927+001	0.
4	8.049-002	1.359+001	0.

FORE END FORCES			AFT END FORCES		
SPL 1 OF 1	AXIAL	SHEAR	MOMENT	J _x	AXIAL
1	1.98+000	3.6+000	2.25+001	4	-1.24+000
2	5.00+900	4.79+000	1.58+002	7	-5.00+900
3	-4.62+000	4.23+000	1.21+002	2	4.62+000
4	-1.29+000	5.29+000	1.68+002	12	1.29+000
5	1.83+000	9.55+000	2.92+001	5	-1.83+000
6	7.44+000	1.26+001	4.32+002	8	-7.44+000
7	-1.43+000	1.34+000	3.23+002	12	1.43+000
8	-2.39+000	1.43+001	4.47+002	13	2.39+000
9	3.61+000	-2.9+000	-2.25+001	2	-3.61+000
10	1.00+001	2.22+001	1.53+001	5	-1.00+001
11	-1.47+000	4.47+002	4.02+001	3	1.47+000
12	1.51+001	-3.50+002	-2.90+000	10	-1.51+001
13	1.01+001	-1.27+001	9.07+000	10	-1.01+001
14	3.71+000	3.47+001	2.50+001	13	-3.71+000
15	2.132+001	6.1+002	4.30+001	3	-2.132+001
16	3.31+001	7.73+002	9.40+000	5	-3.31+001
17	1.03+001	-3.29+003	3.49+001	5	-1.03+001
18	3.73+001	-1.52+002	-1.53+000	11	-3.73+001
19	4.63+001	1.0+002	-9.3+001	11	-4.63+001
20	1.34+001	5.05+002	1.15+001	14	-1.34+001
					-8.05+002
					1.59+001

STATIC ANALYSIS OF GENERAL STRUCTURES
2-D FRAME SAMPLE PROBLEM

SPAN	END	STRESS CALCULATIONS	MY/IN	P/A	SHEAR
1	AFT	-4.473+000	0.	-7.315-001	0.
2	FORE	4.059+000	0.	-1.885+000	0.
3	AFT	-4.024+000	0.	1.771+000	0.
4	FORE	4.333+000	0.	4.830-001	0.
5	AFT	-2.973+000	0.	-2.910-001	0.
6	FORE	2.771+000	0.	-1.149+000	0.
7	AFT	-2.777+000	0.	2.825+000	0.
8	FORE	2.863+000	0.	3.686-001	0.
9	FORE	-5.274+000	0.	-1.532+000	0.
10	FORE	1.232+000	0.	-2.875+000	0.
11	AFT	4.767-001	0.	4.221-001	0.
12	AFT	-3.911-001	0.	-4.335+000	0.
13	FORE	-6.473-001	0.	-2.435+000	0.
14	FORE	6.071+000	0.	-1.553+000	0.
15	FORE	-2.051+000	0.	5.339+000	0.
16	FORE	7.123-001	0.	-1.035+001	0.
17	AFT	-1.312-001	0.	2.957-001	0.
18	AFT	-1.522-001	0.	1.079+001	0.
19	AFT	1.622-001	0.	-1.328+001	0.
20	FORE	2.702+000	0.	5.503+000	0.

STOP
SOL5:263.4
OFF

USAGE ON 09/12/75 AT 13:31:04
SRJIS:304.4 ELAPSED TIME: 00:29:27
END BYE

PROJECT _____

ITEM _____

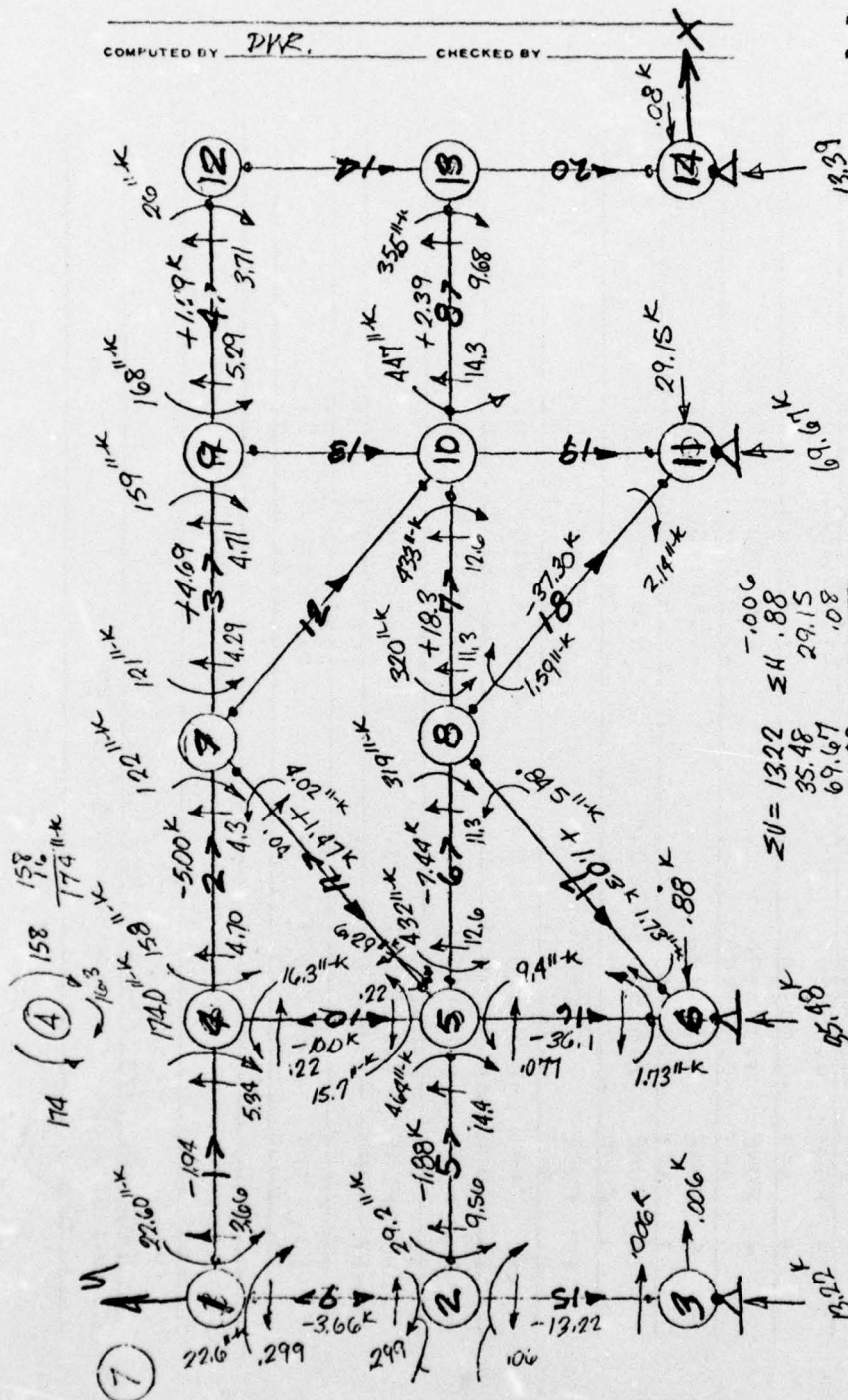
COMPUTED BY DWR. CHECKED BY _____

SHEET NO. _____ OF _____ SHEETS

DATE _____ 19 _____

FILE _____

REF. DRWG. NO. _____



$$\begin{aligned} \sum U &= 13.22 \pm 4.88 \\ &= 35.48 \\ &= 69.67 \\ &= 13.39 \end{aligned}$$

SAGS LOADING CASE #4.

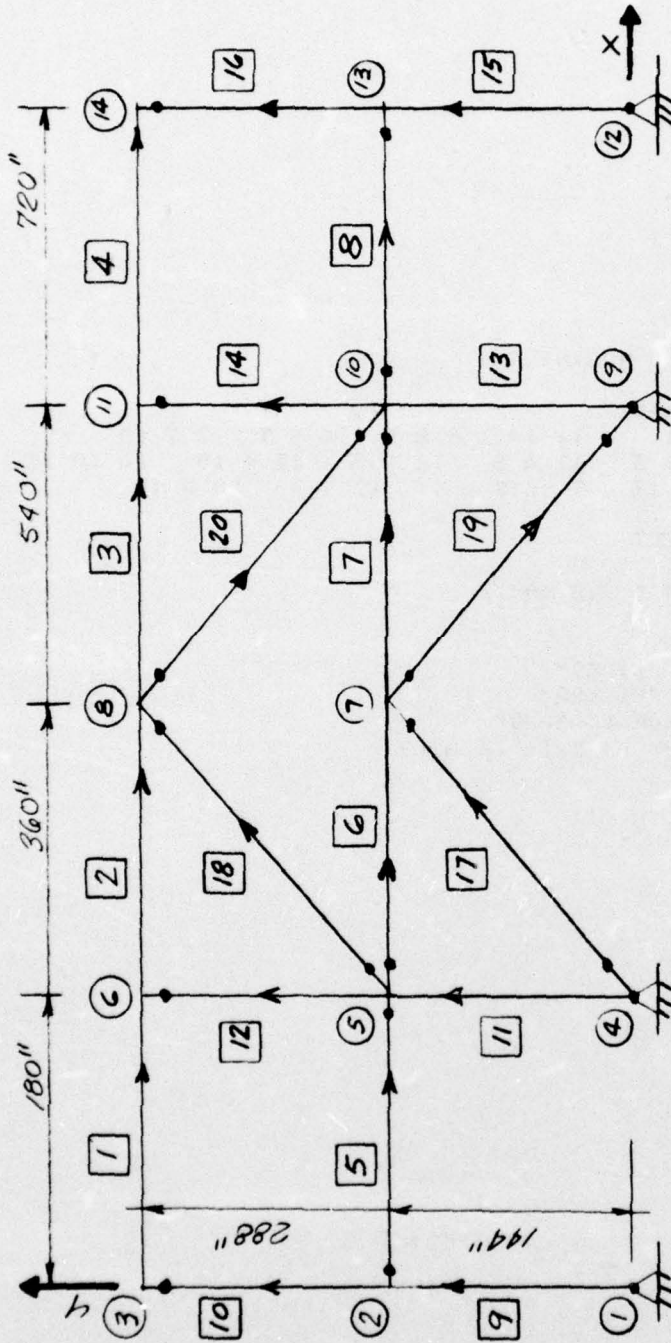
D.L. + L.L. + E.Q.

$$\begin{aligned} &4.64 \quad 15.7 \text{ K} \\ &432 \text{ K} \\ &9.4 \text{ K} \\ &15.70 \\ &463.39 \end{aligned}$$

$$\begin{aligned} &319 \quad 1.59 \quad 320 \\ &320.59 \quad 845 \quad 1.59 \quad 320 \\ &320.8 \end{aligned}$$

PROJECT 2-D FRAME SAMPLE PROBLEM
 ITEM STRUDAL
ST. LOUIS, DISTRICT
 COMPUTED BY HARTMAN CHECKED BY _____

SHEET NO. ____ OF ____ SHEETS
 DATE _____, 19____
 FILE _____
 REF. DRWG. NO. _____



COMPUTER MODEL SAMPLE PROGRAM.
 2-STORY, 2-D FRAME

#LNH JPHSTR

STRUCL INPUT FILE

100 STRUCL '2D FRAME'
110 UNITS FEET
120 JOINT COORD
130 1 0. 0. S
140 2 0. 12.
150 3 0. 24.
160 4 15. 0. S
170 5 15. 12.
180 6 15. 24.
190 7 30. 12.
200 8 30. 24.
210 9 45. 0. S
220 10 45. 12.
230 11 45. 24.
240 12 60. 0. S
250 13 60. 12.
260 14 60. 24.
270 JOINT 1 4 9 12 RELEASES MOMENT Z
280 TYPE PLANE FRAME
290 MULTIPLE MEMBER INCIDENCES
300 1 3 6 2 6 8 3 8 11 4 11 14 5 2 5 6 5 7 7 7 10
310 8 10 13 9 1 2 10 2 3 11 4 5 12 5 6 13 9 10 14 10 11
320 15 12 13 16 13 14 17 4 7 18 5 8 19 7 9 20 8 10
330 MEM RELEASES
340 7 10 12 14 16 END MOMENT Z
350 6 START MOMENT Z
360 5 8 17 TO 20 START MOM Z END MOM Z
370 UNITS INCH KIPS
380 MEM PROP
390 1 TO 4 TABLE 'STEELM' 'M10X9'
400 5 TO 8 TABLE 'STEELW' 'W12X22'
410 9 10 15 16 PRISM AX 3.09 IZ 5.29
420 11 TO 14 17 TO 20 PRISM AX 8.14 IZ 25.7
430 CONSTANTS E 30000. ALL
440 UNITS FEET
450 LOADING 4 'EARTHQUAKE'
460 JOINT LOADS
470 3 14 FORCE X 1.64
480 6 8 11 FOR X 3.28
490 2 13 FORCE X 2.12
500 5 7 10 FOR X 4.23
510 LOADING 3 'WIND'
520 JOINT LOADS
530 3 FOR X 1.96
540 14 FOR X 1.30
550 6 8 11 FOR X 1.40
560 2 FOR X 3.92
570 13 FOR X 2.60
580 5 7 10 FOR X 2.79

590 LOADING 5 'LIVE + DEAD'
600 MEMBER LOADS
610 1 TO 4 FORCE Y GLOBAL UNI --.600
620 5 TO 8 FOR Y GLO UNI -1.6
630 LOAD COMB 6 'D+L+W' COMB 3 1.0 5 1.0
640 LOAD COMB 8 'D+L+W/2' COMB 3 0.5 5 1.0
650 LOAD COMB 10 'D+L+E' COMB 4 1.0 5 1.0
660 LOAD COMB 12 'D+L+E/2' COMB 4 0.5 5 1.0
670 STIFFNESS ANALYSIS
680 UNITS INCH LB
690 OUTPUT DECIMAL 4
700 LIST DISPL FORCES REAC
710 SECTION FR NS 3 0.0 0.5 1.0
720 PARAMETERS
730 'FYLD' 50000. ALL
740 'CODE' 'SP69' ALL
750 CHECK CODE MEM 1 TO 8
760FINISH

.....
MCDONNELL-ECI TICS EXECUTIVE SYSTEM

MAC REL. 2.3 - RELEASED 2/5/73

TIME 11.0A.32, 9/10/75
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* * * * *
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MCDONNELL-ECI	ICES	STRUOL
STRUOL	REL 2.7	
STRUOL DYNAL	REL 4.1	
STRUOL PLOTS	REL 1.12	
	11.08.55	9/10/75
SIZE OF POOL	30640 BYTES	

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* * * * *
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JOINT COMMO

20. 12.

19. 0.

615, 24, 9

8 30. 24.

10 45. 12.

12 00. 0. 3

14 00. 20.

Z. LYNAMON 638V373N 21 6 7 1 LNIOR

TYPE PLANE FRAME

MULTIPLE MEMBER INCIDENCES

1 3 6 2 6 6 3 6 11 4 11 14 5 2 5 6 5 7 7 7 10

8 10 13 9 1 2 10 2 3 11 4 5 12 5 6 13 9 10 14 10 11

15 12 13 16 13 14 17 4 7 18 5 8 19 7 9 20 8 10

MEM RELEASES

7 10 12 14 16 END MOMENT Z

6 START MOMENT Z

5 8 17 TO 20 START MOM Z END MOM Z

UNITS INCH KIPS

MEM PRUP

1 TO 4 TABLE 'STEELW' 11X10X91

5 TO 8 TABLE 'STEELW' 11X12X221

9 10 13 16 PRISM AX 3.09 12 5.29

11 TO 14 17 TO 20 PRISM AX 8.14 12 25.7

CONSTANTS E 30000. ALL

UNITS FEET

LOADING 4 'EARTHQUAKE'

JOINT LOADS

3 14 FORCE X 1.64

6 8 11 FOR X 3.26

2 13 FORCE X 2.12

5 7 10 FOR X 4.23

LOADING 3 'WIND'

JOINT LOADS

3 FOR X 1.96
 14 FOR X 1.30
 6 C 11 FOR X 1.40
 2 FOR X 3.92
 13 FOR X 2.60
 5 7 10 FOR X 2.79
 LOADING 5 'LIVE + DEAD'
 MEMBER LOADS
 1 TO 4 FORCE Y GLOBAL UNI = .600
 5 TO 8 FOR Y GLD UNI = 1.6
 LOAD CUMB 6 'D+L+W' COMB 3 1.0 5 1.0
 LOAD CUMB 8 'D+L+W/2' COMB 3 0.5 5 1.0
 LOAD CUMB 10 'D+L+E' COMB 4 1.0 5 1.0
 LOAD CUMB 12 'D+L+E/2' COMB 4 0.5 5 1.0
 STIFFNESS ANALYSIS
 **** -BENDING - DEFAULT CHANGED TO "WITH REACTIONS"
 SPECIFY "WITHOUT REACTIONS" IF REACTIONS NOT DESIRED
 UNITS INCH LB
 OUTPUT DECIMAL 4
 LIST DISPL FORCES REAC

RESULTS OF LATEST ANALYSIS*

PROBLEM - 2D FRAME TITLE - NONE GIVEN

ACTIVE UNITS INCH LB RAD PAIR SEC LBM

LOADING - 8 EARTHQUAKE

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	MOMENT	BENDING Y	BENDING Z
1	3	1640.9272	-1.8344						-0.0000
1	6	-1640.9272	1.8344						-330.1997
2	6	4925.3516	1.8344						330.1997
2	8	-4925.3516	-1.8344						-0.0000
3	6	-4925.3516	1.8344						-0.0000
3	11	4925.3516	-1.8344						330.1997
4	11	-1640.9272	1.8344						-330.1997
4	14	1640.9272	-1.8344						-0.0000
5	2	2118.1436	-0.0000						0.0
5	5	-2118.1436	0.0000						-0.0000
6	5	12904.6367	-0.0000						-0.0000
6	7	-12904.6367	0.0000						-0.0000
7	7	12904.6367	-0.0000						-0.0000
7	10	-12904.6367	0.0000						0.0
8	10	2118.1436	-0.0000						0.0
8	13	-2118.1436	0.0000						-0.0000
9	1	-1.8344	0.9280						-0.0000
9	2	1.8344	-0.9280						0.0000
10	2	-1.8344	-0.9280						133.9346
10	3	1.8344	0.9280						-133.9346
11	4	-5248.6094	4.4259						0.0
11	5	5248.6094	-4.4259						0.0000
11	5								637.3323
12	5	3.6689	-4.4259						-637.3323

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE SHEAR Y	SHEAR Z	TORSIONAL	MOMENT BENDING Y	BENDING Z
12	6	-3.6689	4.4259				0.0
13	9	5248.6094	4.4259				0.0000
13	10	-5248.6094	-4.4259				637.3323
14	10	-3.6689	-4.4259				-637.3323
14	11	3.6689	4.4259				0.0
15	12	1.8344	0.9280				0.0000
15	13	-1.8344	-0.9280				133.6346
16	13	1.8344	-0.9280				-133.6346
16	14	-1.8344	0.9280				0.0
17	4	-19234.5195	0.0000				-0.0000
17	7	19234.5195	-0.0000				0.0000
18	5	-8407.7500	0.0000				0.0000
18	8	8407.7500	-0.0000				0.0000
19	7	19234.5195	-0.0000				0.0
19	9	-19234.5195	0.0000				-0.0000
20	8	8407.7500	-0.0000				0.0000
20	10	-8407.7500	0.0000				-0.0000

RESULTANT JOINT LOADS - SUPPORTS

JOINT	X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
1	GLOBAL	-0.9280				0.0000
4	GLOBAL	-15024.0625	-17264.3203			0.0000
9	GLOBAL	-15024.0625	17264.3203			0.0000
12	GLOBAL	-0.9280	1.8344			0.0000

RESULTANT JOINT DISPLACEMENTS - SUPPORTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
1	GLOBAL	0.0	0.0			-0.0003
4	GLOBAL	0.0	0.0			-0.0003
9	GLOBAL	0.0	0.0			-0.0003
12	GLOBAL	0.0	0.0			-0.0003

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT		X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
2	GLOBAL	0.0372	0.0000				-0.0002
3	GLOBAL	0.0627	0.0000				0.0000
5	GLOBAL	0.0352	0.0031				-0.0002
6	GLOBAL	0.0590	0.0031				-0.0000
7	GLOBAL	0.0233	0.0000				-0.0000
8	GLOBAL	0.0479	0.0000				-0.0000
10	GLOBAL	0.0352	-0.0031				-0.0002
11	GLOBAL	0.0590	-0.0031				-0.0000
13	GLOBAL	0.0372	0.0000				-0.0002
14	GLOBAL	0.0627	-0.0000				0.0000

LOADING - 3 WIND

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	MOMENT	BENDING Y	BENDING Z
1	3	1961.2415	-0.6641						-0.0000
1	6	-1961.2415	0.6641						-119.5292
2	6	3366.1836	0.0280						119.5292
2	8	-3366.1836	-0.0280						-114.4953
3	8	-2705.6658	2.0598						114.4953
3	11	2705.6658	-2.0598						-258.2622
4	11	-1301.0901	-1.4237						-258.2622
4	14	1301.0901	1.4237						-0.0000
5	2	3917.5137	-0.0000						0.0
5	5	-3917.5137	0.0000						-0.0000
6	5	10432.2813	0.0005						-0.0000
6	7	-10432.2813	-0.0005						0.0953
7	7	-9115.8555	0.0005						-0.0953
7	10	9115.8555	-0.0005						0.0
8	10	-2597.8167	-0.0000						0.0
8	13	2597.8167	0.0000						-0.0000
9	1	-0.6641	1.2426						0.0000
9	2	0.6641	-1.2426						178.9369
10	2	-0.6641	-1.2426						-178.9369
10	3	0.6641	1.2426						0.0
11	4	-2987.0313	4.9426						0.0000
11	5	2987.0313	-4.9426						711.7383

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE SHEAR Y	SHEAR Z	TORSIONAL	MOMENT BENDING Y	MOMENT BENDING Z
12	5	0.6920	-4.9426				-711.7363
12	6	-0.6920	4.9426				0.0
13	9	2986.2725	4.5762				0.0000
13	10	-2986.2725	-4.5762				656.9731
14	10	-3.4834	-4.5762				-656.9731
14	11	3.4834	4.5762				0.0
15	12	1.4237	1.0912				0.0000
15	13	-1.4237	-1.0912				157.1356
16	13	1.4237	-1.0912				-157.1356
16	14	-1.4237	1.0912				0.0
17	4	-14303.3867	0.0000				0.0
17	7	14303.3867	-0.0000				0.0000
18	5	-4762.6914	0.0000				-0.0000
18	8	4762.6914	-0.0000				0.0000
19	7	14303.3867	-0.0000				0.0
19	9	-14303.3867	0.0000				-0.0000
20	8	4765.9414	-0.0000				0.0000
20	10	-4765.9414	0.0000				-0.0000

RESULTANT JOINT LOADS - SUPPORTS

JOINT	X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
1	GLOBAL	-1.2426				0.0000
4	GLOBAL	-11174.0117	-0.6641			0.0000
9	GLOBAL	-11173.6445	-11922.2852			0.0000
12	GLOBAL	-1.0912	1.4237			0.0000

RESULTANT JOINT DISPLACEMENTS - SUPPORTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
1	GLOBAL	0.0	0.0			-0.0002
4	GLOBAL	0.0	0.0			-0.0002
9	GLOBAL	0.0	0.0			-0.0002
12	GLOBAL	0.0	0.0			-0.0002

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
2	GLOBAL	0.0306	0.0000			-0.0002
3	GLOBAL	0.0456	0.0000			0.0000
5	GLOBAL	0.0270	0.0018			-0.0001
6	GLOBAL	0.0412	0.0018			0.0000
7	GLOBAL	0.0173	0.0000			-0.0000
8	GLOBAL	0.0335	0.0008			-0.0000
10	GLOBAL	0.0257	-0.0018			-0.0001
11	GLOBAL	0.0397	-0.0018			-0.0000
13	GLOBAL	0.0282	-0.0000			-0.0001
18	GLOBAL	0.0426	-0.0000			0.0000

LOADING - S LIVE + DEAD

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	BENDING Y	BENDING Z
1	3	-0.7695	3536.7439					0.0000
1	6	0.7695	5463.2500					-173385.8750
2	6	-4.5096	4823.1406					173385.8750
2	8	4.5096	4176.8515					-115219.8125
3	8	-4.5096	4176.8515					115219.8125
3	11	4.5096	4823.1406					-173385.8750
4	11	-4.5096	5463.2500					173385.8750
4	14	0.7695	3536.7439					-0.0000
5	2	1.5300	11999.9922					0.0000
5	5	-1.5300	11999.9922					0.0000
6	5	-5216.0469	9069.5508					0.0000
6	7	5216.0469	14930.4257					-527478.8125
7	7	-5216.0469	14930.4257					527478.8125
7	10	5216.0469	9069.5508					0.0000
8	10	1.5300	11999.9922					0.0000
8	13	-1.5300	11999.9922					0.0000
9	1	15536.7383	-0.7695					-0.0000
9	2	-15536.7383	0.7695					-110.8060
10	2	3536.7439	0.7695					110.8060
10	3	-3536.7439	-0.7695					0.0000
11	4	35532.7930	-3.7401					-0.0000
11	5	-35532.7930	3.7401					-538.5757

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	MOMENT	BENDING Y	BENDING Z
12	5	10286.3905	3.7401						538.5757
12	6	-10286.3905	-3.7401						0.0
13	9	35532.7930	3.7401						0.0000
13	10	-35532.7930	-3.7401						538.5757
14	10	10286.3905	3.7401						-538.5757
14	11	-10286.3905	-3.7401						0.0
15	12	15536.7305	0.7695						0.0000
15	13	-15536.7305	-0.7695						110.8060
16	13	3530.7422	0.7695						-110.8060
16	14	-3530.7422	-0.7695						0.0
17	4	23900.3477	0.0000						0.0
17	7	-23900.3477	-0.0000						0.0000
18	5	6686.2266	0.0000						0.0
18	8	-6686.2266	-0.0000						0.0000
19	7	23900.3477	0.0000						0.0
19	9	-23900.3477	-0.0000						-0.0000
20	8	6686.2266	0.0000						0.0000
20	10	-6686.2266	-0.0000						-0.0000

RESULTANT JOINT LOADS - SUPPORTS

JOINT	X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
1	GLOBAL	0.7695	15536.7305			-0.0000
4	GLOBAL	18686.7773	50463.2227			-0.0000
9	GLOBAL	-18686.7773	50463.2227			0.0000
12	GLOBAL	-0.7695	15536.7305			0.0000

RESULTANT JOINT DISPLACEMENTS - SUPPORTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
1	GLOBAL	0.0	0.0			0.0001
4	GLOBAL	0.0	0.0			0.0001
9	GLOBAL	0.0	0.0			-0.0001
12	GLOBAL	0.0	0.0			-0.0001

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT		X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
2	GLOBAL	-0.0048	-0.0241				0.0000
3	GLOBAL	-0.0000	-0.0296				-0.0060
5	GLOBAL	-0.0048	-0.0210				0.0000
6	GLOBAL	-0.0000	-0.0270				0.0014
7	GLOBAL	-0.0000	-0.0361				0.0000
8	GLOBAL	-0.0000	-0.0371				0.0000
10	GLOBAL	0.0048	-0.0210				-0.0000
11	GLOBAL	0.0000	-0.0270				-0.0014
13	GLOBAL	0.0048	-0.0241				-0.0000
14	GLOBAL	0.0000	-0.0296				0.0060

LOADING - 6 D/L+H

MEMBER FORCES

MEMBER	JOINT	AXIAL	SHEAR Y	SHEAR Z	TORSIONAL	BENDING Y	BENDING Z
1	3	1900.4719	3536.0798				0.0000
1	6	-1900.4719	5463.9102				-173505.3750
2	6	3361.6738	4923.1690				173505.3750
2	8	-3361.6738	4176.8203				-115334.2500
3	8	-2710.1753	4178.9102				115334.2500
3	11	2710.1753	4921.0781				-173129.5625
4	11	-1301.8594	5461.8242				173129.5625
4	14	1301.8594	3538.1858				-0.0000
5	2	3919.0525	11999.9922				0.0000
5	5	-3919.0525	11999.9993				0.0000
6	5	5220.2344	9069.5507				0.0000
6	7	-5220.2344	14930.4219				0.0000
7	7	-14327.9023	14930.4258				-527478.6875
7	10	14327.9023	9069.5508				527478.6875
8	10	-2596.2776	11999.9922				0.0
8	13	2596.2776	11999.9993				0.0000
9	1	15538.0742	0.4731				0.0000
9	2	-15538.0742	-0.4731				0.0000
10	2	3536.0798	-0.4731				68.1309
10	3	-3536.0798	0.4731				-68.1309
11	4	32545.7617	1.2025				0.0
11	5	-32545.7617	-1.2025				0.0000
							173.1626

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE SHEAR Y	SHEAR Z	TORSIONAL	MOMENT BENDING Y	MOMENT BENDING Z
12	5	10287.0859	-1.2025				-173.1626
12	6	-10287.0859	1.2025				0.0
13	9	38519.0625	0.3193				0.0000
13	10	-38519.0625	-0.3193				1197.5488
14	10	10282.9102	-9.3193				0.0
14	11	-10282.9102	9.3193				0.0000
15	12	15538.1523	1.8607				0.0000
15	13	-15538.1523	-1.8607				267.9414
16	13	3538.1658	-1.8607				-267.9414
16	14	-3538.1658	1.8607				0.0
17	4	9598.9609	0.0000				0.0
17	7	-9598.9609	-0.0000				0.0000
18	5	1903.5352	0.0000				-0.0000
18	8	-1903.5352	-0.0000				0.0000
19	7	38203.7344	-0.0000				0.0
19	9	-38203.7344	0.0000				-0.0000
20	8	11472.1680	-0.0000				0.0000
20	10	-11472.1680	0.0000				-2.0000

RESULTANT JOINT LOADS = SUPPORTS

JOINT	X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
1	GLOBAL	-0.4731	15538.0742			0.0000
4	GLOBAL	7492.7656	38500.9375			0.0000
9	GLOBAL	-29840.4219	62364.7500			0.0000
12	GLOBAL	-1.8607	15538.1523			0.0000

RESULTANT JOINT DISPLACEMENTS = SUPPORTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
1	GLOBAL	0.0	0.0			-0.0002
4	GLOBAL	0.0	0.0			-0.0002
9	GLOBAL	0.0	0.0			-0.0002
12	GLOBAL	0.0	0.0			-0.0003

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
2	GLOBAL	0.0258	-0.0241			-0.0002
3	GLOBAL	0.0456	-0.0296			-0.0060
5	GLOBAL	0.0221	-0.0192			-0.0001
6	GLOBAL	0.0412	-0.0253			0.0014
7	GLOBAL	0.0173	-0.0361			-0.0000
8	GLOBAL	0.0335	-0.0363			-0.0000
10	GLOBAL	0.0306	-0.0227			-0.0001
11	GLOBAL	0.0397	-0.0288			-0.0014
13	GLOBAL	0.0330	-0.0241			-0.0001
14	GLOBAL	0.0426	-0.0296			0.0000

LOADING - B D+Lw/2

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	MOMENT	BENDING Y	BENDING Z
1	3	979.8511	3536.4119						0.0000
1	6	-979.8511	5463.5781						-173485.6250
2	6	1678.5820	4823.1523						173485.6250
2	8	-1678.5820	4176.8359						-115277.0000
3	8	-1357.3423	4177.8789						115277.0000
3	11	1357.3423	4822.1094						-173257.6875
4	11	-651.3142	5462.5352						173257.6875
4	14	651.3142	3537.4539						-0.0000
5	2	1960.2957	11999.9922						0.0000
5	5	-1960.2957	11999.9883						0.0000
6	5	4.0938	9069.5547						0.0000
6	7	-4.0938	14930.4219						-527478.7500
7	7	-9769.8727	14930.4258						527478.7500
7	10	9769.8727	9069.5508						0.0
8	10	-1297.3691	11999.9922						0.0000
8	13	1297.3691	11999.9883						0.0000
9	1	-15536.4063	-0.1482						-21.3376
9	2	15536.4063	0.1482						21.3376
10	2	3536.4119	0.1482						0.0
10	3	-3536.4119	-0.1482						-0.0000
11	4	34039.2773	-1.2688						-0.0000
11	5	-34039.2773	1.2688						-182.7065

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	MOMENT	BENDING Y	BENDING Z
12	5	10286.7303	1.2668						182.7065
12	6	-10286.7303	-1.2668						0.0
13	9	37025.9258	6.0282						0.0000
13	10	-37025.9258	-6.0282						868.0623
14	10	10284.6523	-6.0282						-868.0623
14	11	-10284.6523	6.0282						0.0
15	12	15537.4414	1.3151						0.0000
15	13	-15537.4414	-1.3151						0.0000
16	13	3537.4539	-1.3151						189.3738
14	14	-3537.4539	1.3151						-189.3738
17	4	16748.6563	0.0000						0.0
17	7	-16748.6563	-0.0000						0.0
18	5	4294.8789	0.0000						0.0000
18	8	-4294.8789	-0.0000						-0.0000
19	7	31052.0391	-0.0000						0.0
19	9	-31052.0391	0.0000						-0.0000
20	8	9079.1953	-0.0000						0.0000
20	10	-9079.1953	0.0000						-0.0000

RESULTANT JOINT LOADS - SUPPORTS

JOINT	X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
1	GLOBAL	0.1882	15536.6063			0.0000
6	GLOBAL	13079.7734	40502.0820			-0.0000
9	GLOBAL	-24253.5977	50423.9844			0.0000
12	GLOBAL	-1.3151	15537.4414			0.0000

RESULTANT JOINT DISPLACEMENTS - SUPPORTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
1	GLOBAL	0.0	0.0			-0.0001
6	GLOBAL	0.0	0.0			-0.0001
9	GLOBAL	0.0	0.0			-0.0001
12	GLOBAL	0.0	0.0			-0.0002

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
2	GLOBAL	0.0105	-0.0241			-0.0001
3	GLOBAL	0.0228	-0.0296			-0.0060
5	GLOBAL	0.0086	-0.0201			-0.0001
6	GLOBAL	0.0206	-0.0261			0.0014
7	GLOBAL	0.0086	-0.0361			-0.0000
8	GLOBAL	0.0168	-0.0367			-0.0000
10	GLOBAL	0.0177	-0.0218			-0.0001
11	GLOBAL	0.0198	-0.0279			-0.0014
13	GLOBAL	0.0189	-0.0241			-0.0001
14	GLOBAL	0.0213	-0.0296			0.0060

LOADING - 10 D+L+E

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	MOMENT	BENDING Y	BENDING Z
1	3	1640.1577	3534.9094					0.0000	
1	6	-1640.1577	5465.0820					-173716.0625	
2	6	4920.8398	4824.9727					173716.0625	
2	8	-4920.8398	4175.0156					-115219.6125	
3	8	-4929.8594	4178.6836					115219.6125	
3	11	4929.8594	4821.3047					-173055.6250	
4	11	-1641.6965	5461.4141					173055.6250	
4	14	1641.6965	3538.5764					-0.0000	
5	2	2119.6824	11999.9922					0.0000	
5	5	-2119.6824	11999.9983					0.0000	
6	5	7692.5898	9069.5547					0.0000	
6	7	-7692.5898	14930.4258					-527478.6125	
7	7	18116.6836	14930.4297					527478.6125	
7	10	18116.6836	9069.5508					0.0	
8	10	-2116.6045	11999.9922					0.0000	
8	13	2116.6045	11999.9883					0.0000	
9	1	15534.9023	0.1585					0.0000	
9	2	-15534.9023	-0.1585					0.0000	
10	2	3534.9094	-0.1585					22.8246	
10	3	-3534.9094	0.1585					-22.8246	
11	4	30284.1836	0.6858					0.0	
11	5	-30284.1836	-0.6858					0.0000	
								99.7566	

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	MOMENT	BENDING Y	BENDING Z
12	5	10290.0625	-0.6858						-98.7566
12	6	-10290.0625	0.6858						0.0
13	9	40781.4023	8.1660						0.0000
13	10	-40781.4023	-8.1660						1175.9080
14	10	10282.7227	-8.1660						-1175.9080
14	11	-10282.7227	8.1660						0.0
15	12	15538.5625	1.6975						0.0000
15	13	-15538.5625	-1.6975						244.4406
16	13	3538.5764	1.6975						-244.4406
16	14	-3538.5764	-1.6975						0.0
17	4	4665.8281	0.0000						-0.0000
17	7	-4665.8281	-0.0000						0.0000
18	5	-1721.5234	0.0000						0.0000
18	8	1721.5234	-0.0000						0.0000
19	7	43134.8672	-0.0000						0.0
19	9	-43134.8672	0.0000						-0.0000
20	8	15093.9766	-0.0000						0.0000
20	10	-15093.9766	0.0000						-0.0000

RESULTANT JOINT LOADS - SUPPORTS

JOINT	X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
1	GLOBAL	-0.1505	15534.9023			0.0000
4	GLOBAL	3642.7148	33198.9023			0.0000
9	GLOBAL	-33690.6398	67727.5000			0.0000
12	GLOBAL	-1.6975	15538.5625			0.0000

RESULTANT JOINT DISPLACEMENTS - SUPPORTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
1	GLOBAL	0.0	0.0			-0.0002
4	GLOBAL	0.0	0.0			-0.0002
9	GLOBAL	0.0	0.0			-0.0003
12	GLOBAL	0.0	0.0			-0.0003

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
2	GLOBAL	0.0324	-0.0241			-0.0002
3	GLOBAL	0.0627	-0.0296			-0.0060
5	GLOBAL	0.0304	-0.0179			-0.0002
6	GLOBAL	0.0590	-0.0239			0.0014
7	GLOBAL	0.0233	-0.0361			-0.0000
8	GLOBAL	0.0474	-0.0371			-0.0000
10	GLOBAL	0.0401	-0.0240			-0.0002
11	GLOBAL	0.0590	-0.0301			-0.0014
13	GLOBAL	0.0420	-0.0241			-0.0002
14	GLOBAL	0.0627	-0.0296			0.0061

LOADING - 12 D+L+E/2

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	BENDING Y	BENDING Z
1	3	819.6941	3535.8267					0.0000
1	6	-819.6941	5468.1641					-173550.9375
2	6	2458.1660	4824.0547					173550.9375
2	8	-2458.1660	4175.9336					-115219.8125
3	8	-2467.1853	4177.7656					115219.8125
3	11	2467.1853	4822.2227					-173220.7500
4	11	-821.2329	5462.3320					173220.7500
4	14	821.2329	3537.6592					-0.0000
5	2	1060.6106	11999.9922					0.0000
5	5	-1060.6106	11999.9983					0.0000
6	5	1240.2695	9069.5547					0.0000
6	7	-1240.2695	14930.4258					-527478.8125
7	7	-11664.3633	14930.4297					527478.8125
7	10	11664.3633	9069.5508					0.0000
8	10	-1057.5327	11999.9922					0.0000
8	13	1057.5327	11999.9983					0.0000
9	1	15535.8203	-0.3055					0.0000
9	2	-15535.8203	0.3055					-43.9887
10	2	3535.8267	0.3055					43.9887
10	5	-3535.8267	-0.3055					0.0000
11	4	32908.4883	-1.5272					0.0000
11	5	-32908.4883	1.5272					-219.9097

MEMBER FORCES

MEMBER	JOINT	AXIAL	FORCE	SHEAR Y	SHEAR Z	TORSIONAL	MOMENT	BENDING Y	BENDING Z
12	5	10288.2266	1.5272						219.9087
12	6	-10288.2266	-1.5272						0.0
13	9	38157.0977	5.9331						0.0000
13	10	-38157.0977	-5.9331						857.2417
14	10	10284.5586	-5.9331						-857.2417
14	11	-10284.5586	5.9331						0.0
15	12	15537.6445	1.2335						0.0000
15	13	-15537.6445	-1.2335						177.6233
16	13	3537.6592	-1.2335						-177.6233
16	14	-3537.6592	1.2335						0.0
17	6	14283.0898	0.0000						-0.0000
17	7	-14283.0898	-0.0000						0.0000
18	5	2882.3516	0.0000						0.0000
18	6	-2882.3516	-0.0000						0.0000
19	7	33517.6055	-0.0000						0.0
19	8	-33517.6055	0.0000						-0.0000
20	8	10890.1016	-0.0000						0.0000
20	10	-10890.1016	0.0000						-0.0000

RESULTANT JOINT LOADS - SUPPORTS

JOINT	X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
1	GLOBAL	0.3055	15535.8203			0.0000
4	GLOBAL	11154.7461	41831.0625			0.0000
9	GLOBAL	-26178.8086	59095.3828			0.0000
12	GLOBAL	-1.2335	15537.6445			0.0000

RESULTANT JOINT DISPLACEMENTS - SUPPORTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
1	GLOBAL	0.0	0.0			-0.0001
4	GLOBAL	0.0	0.0			-0.0001
9	GLOBAL	0.0	0.0			-0.0002
12	GLOBAL	0.0	0.0			-0.0002

RESULTANT JOINT DISPLACEMENTS - FREE JOINTS

JOINT	X DISP	Y DISP	Z DISP	X ROT	Y ROT	Z ROT
2	GLOBAL	0.0138	-0.0241			-0.0001
3	GLOBAL	0.0314	-0.0296			-0.0000
5	GLOBAL	0.0128	-0.0194			-0.0001
6	GLOBAL	0.0295	-0.0255			0.0014
7	GLOBAL	0.0116	-0.0361			-0.0000
8	GLOBAL	0.0239	-0.0371			-0.0000
10	GLOBAL	0.0274	-0.0225			-0.0001
11	GLOBAL	0.0295	-0.0286			-0.0014
13	GLOBAL	0.0234	-0.0241			-0.0001
14	GLOBAL	0.0314	-0.0296			0.0000

SECTION FR NS 3 0.0 0.5 1.0

PARAMETERS

'PYLO' 50000. ALL

'CODE' 'SP001' ALL

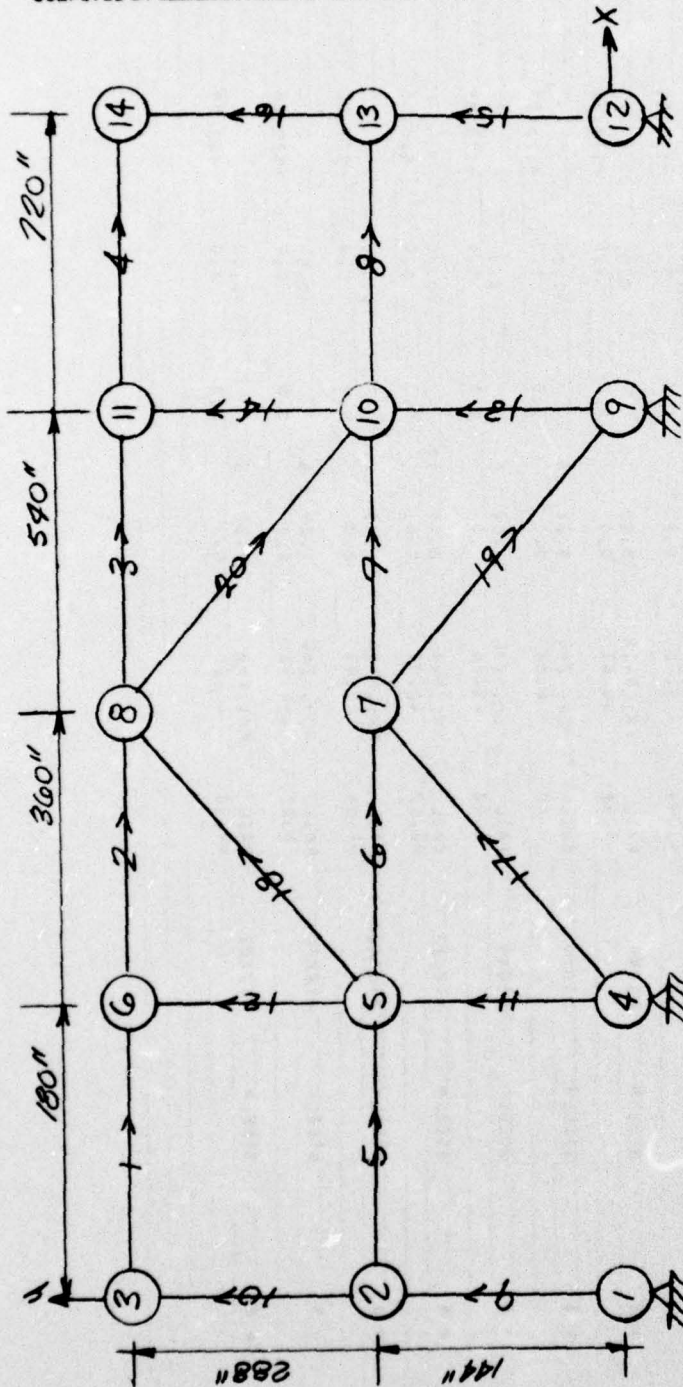
CHECK CODE MEM 1 TO 8

 * STRUDL CODE CHECK OPERATIONAL UNITS INCHES KIPS *

MEMBER	MATERIAL	PROFILE	CHECK RESULT FX	CRITICAL COND. FY	RATIO FZ	LOADING MX	LOCATION MY	MZ
* 1	STEELM	M10X9	FAIL	PM1.0-1A 5.46	3.71 0.0	6 0.0	100.00 0.0	-173.31
* 2	STEELM	M10X9	FAIL	PM1.0-1A -4.82	6.25 0.0	10 0.0	0.0 0.0	-173.72
* 3	STEELM	M10X9	FAIL	MM, Z-C 4.82	5.21 0.0	5 0.0	100.00 0.0	-173.39
* 4	STEELM	M10X9	FAIL	MM, Z-C -5.46	3.53 0.0	5 0.0	0.0 0.0	-173.39
* 5	STEELM	M12X22	FAIL	PM1.0-2 -0.00	2.40 0.0	10 0.0	0.0 0.0	540.00
* 6	STEELM	M12X22	FAIL	PM1.0-1A 14.93	1.45 0.0	10 0.0	100.00 0.0	-527.88
* 7	STEELM	M12X22	FAIL	MM, Z-C -14.93	1.29 0.0	5 0.0	0.0 0.0	-527.88
* 8	STEELM	M12X22	FAIL	PM1.0-2 -0.00	2.31 0.0	5 0.0	0.0 0.0	540.00

PROJECT 2-D FRAME SAMPLE PROBLEM
 ITEM NASTRAN
ST. LOUIS DISTRICT
 COMPUTED BY HARTMAN. CHECKED BY _____

SHEET NO. _____ OF _____ SHEETS
 DATE _____ 19____
 FILE _____
 REF. DRWG. NO. _____



COMPUTER MODEL SAMPLE PROGRAM
 2-STORY, 2-D FRAME.

#LNH JPHNAS

100ID FRAME NASTRAN
 110SOL 1,0
 120TIME 3
 130CEND
 140OUTPUT
 150SET 1 = 1,4,9,12
 160DISPLACEMENT=ALL
 170ELFORCE=ALL
 180SPCFORCE = 1
 190SUBCASE 1
 200 LOAD=3
 210SUBCASE 2
 220 LOAD=4
 230SUBCASE 3
 240 LOAD=5
 250SUBCOM 6
 260 SUBSEQ=1.0,0.0,1.0
 270SUBCOM 8
 280 SUBSEQ=0.5,0.0,1.0
 290SUBCOM 10
 300 SUBSEQ=0.0,1.0,1.0
 310SUBCOM 12
 320 SUBSEQ=0.0,0.5,1.0
 330BEGIN BULK

340GRDSET					345
350GRID	1	0.	0.	0.	12345
360GRID	2	0.	144.	0.	
370GRID	3	0.	288.	0.	
380GRID	4	180.	0.	0.	12345
390GRID	5	180.	144.	0.	
400GRID	6	180.	288.	0.	
410GRID	7	360.	144.	0.	
420GRID	8	360.	288.	0.	
430GRID	9	540.	0.	0.	12345
440GRID	10	540.	144.	0.	
450GRID	11	540.	288.	0.	
460GRID	12	720.	0.	0.	12345
470GRID	13	720.	144.	0.	
480GRID	14	720.	288.	0.	
490BARBR				-1.	1. 0.
1					
500CBAR	1	1	3	6	
510CBAR	2	1	6	8	
520CBAR	3	1	8	11	
530CBAR	4	1	11	14	
540CBAR	5	2	2	5	
C1					
550+1	6	6			
560CBAR	6	2	5	7	
C2					
570+2	6				
580CBAR	7	2	7	10	
C3					
590+3	6				
600CBAR	8	2	10	13	
C4					

610+4	6	6						
620CBAR		9	3	1	2			
630CBAR		10	3	2	3			
C5								
640+5		6						
650CBAR		11	4	4	5			
660CBAR		12	4	5	6			
C6								
670+6		6						
680CBAR		13	4	9	10			
690CBAR		14	4	10	11			
C7								
700+7		6						
710CBAR		15	3	12	13			
720CBAR		16	3	13	14			
C8								
730+8		6						
740CROD		17	1	4	7	18	1	5
8								
750CROD		19	1	7	9	20	1	8
10								
760PBAR		1	1	2.65	38.8			
770PBAR		2	1	6.47	25.3			
780PBAR		3	1	3.09	5.29			
790PBAR		4	1	8.14	25.7			
800PROD		1	1	8.14				
810MAT1		1	3.E+07					
830FORCE		3	3		1960.	1.	0.	0.
840FORCE		3	6		1400.	1.	0.	0.
850FORCE		3	8		1400.	1.	0.	0.
860FORCE		3	11		1400.	1.	0.	0.
870FORCE		3	14		1300.	1.	0.	0.
880FORCE		3	2		3920.	1.	0.	0.
890FORCE		3	5		2790.	1.	0.	0.
900FORCE		3	7		2790.	1.	0.	0.
910FORCE		3	10		2790.	1.	0.	0.
920FORCE		3	13		2600.	1.	0.	0.
930FORCE		4	3		1640.	1.	0.	0.
940FORCE		4	6		3280.	1.	0.	0.
950FORCE		4	8		3280.	1.	0.	0.
960FORCE		4	11		3280.	1.	0.	0.
970FORCE		4	14		1640.	1.	0.	0.
980FORCE		4	2		2120.	1.	0.	0.
990FORCE		4	5		4230.	1.	0.	0.
1000FORCE		4	7		4230.	1.	0.	0.
1010FORCE		4	10		4230.	1.	0.	0.
1020FORCE		4	13		2120.	1.	0.	0.
1030PLOAD1		5	1	FY	LE	0.	-50.	180.
-50.								

1040PLOAD1	5	2	FY	LE	0.	-50.	180.	
-50.								
1050PLOAD1	5	3	FY	LE	0.	-50.	180.	
-50.								
1060PLOAD1	5	4	FY	LE	0.	-50.	180.	
-50.								
1070PLOAD1	5	5	FY	LE	0.	-133.3	180.	-1
33.3								
1080PLOAD1	5	6	FY	LE	0.	-133.3	180.	-1
33.3								
1090PLOAD1	5	7	FY	LE	0.	-333.3	180.	-1
33.3								
1100PLOAD1	5	8	FY	LE	0.	-133.3	180.	-1
33.3								
1110ENDDATA								

#BYE

MRU = .713 CON= :22

```

      N A S T R A N
      MSC -27
      VERSION FEB 26, 1975
      IBM 360-370 SERIES
      MODEL 168
  
```

SEPTEMBER 12, 1975 NASTRAN 2/26/75 PAGE 1

NASTRAN EXECUTIVE CONTROL DECK ECHO

```

ID FRAME NASTRAN
SOL 1,0
TIME 3
CEND
  
```

CASE CONTROL DECK ECHU

CARD COUNT	OUTPUT
1	SET 1 # 1,4,9,12
2	DISPLACEMENT#ALL
3	ELFORCE#ALL
4	SPCFORCE # 1
5	SUBCASE 1
6	LOAD#1
7	SUBCASE 2
8	LOAD#2
9	SUBCASE 3
10	LOAD#3
11	SUBCASE 4
12	LOAD#4
13	SUBCASE 5
14	LOAD#5
15	SUBCASE 6
16	LOAD#6
17	SUBCASE 7
18	LOAD#7
19	SUBCASE 8
20	LOAD#8
21	SUBCASE 9
22	LOAD#9
23	SUBCASE 10
24	LOAD#10
25	SUBCASE 11
26	LOAD#11
27	SUBCASE 12
28	LOAD#12
29	SUBCASE 13
30	LOAD#13
31	SUBCASE 14
32	LOAD#14
33	SUBCASE 15
34	LOAD#15
35	SUBCASE 16
36	LOAD#16
37	SUBCASE 17
38	LOAD#17
39	SUBCASE 18
40	LOAD#18
41	SUBCASE 19
42	LOAD#19
43	SUBCASE 20
44	LOAD#20
45	SUBCASE 21
46	LOAD#21
47	SUBCASE 22
48	LOAD#22
49	SUBCASE 23
50	LOAD#23
51	SUBCASE 24
52	LOAD#24
53	SUBCASE 25
54	LOAD#25
55	SUBCASE 26
56	LOAD#26
57	SUBCASE 27
58	LOAD#27
59	SUBCASE 28
60	LOAD#28
61	SUBCASE 29
62	LOAD#29
63	SUBCASE 30
64	LOAD#30
65	SUBCASE 31
66	LOAD#31
67	SUBCASE 32
68	LOAD#32
69	SUBCASE 33
70	LOAD#33
71	SUBCASE 34
72	LOAD#34
73	SUBCASE 35
74	LOAD#35
75	SUBCASE 36
76	LOAD#36
77	SUBCASE 37
78	LOAD#37
79	SUBCASE 38
80	LOAD#38
81	SUBCASE 39
82	LOAD#39
83	SUBCASE 40
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85	SUBCASE 41
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449	SUBCASE 223
450	LOAD#223
451	SUBCASE 224
452	LOAD#224
453	SUBCASE 225
454	LOAD#225
455	SUBCASE 226
456</	

CARD COUNT	1	2	3	4	5	6	7	8	9	10	
10	CHAR	1	3	3	5	1	1	0.0	9	10	
20	CHAR	2	6	6	7	10	13				C1
30	CHAR	3	11	11	14	5					C2
40	CHAR	4	14	14	5						C3
50	CHAR	5	2	2	5	7					C4
60	CHAR	6	2	2	5	7					C5
70	CHAR	7	2	2	5	7					C6
80	CHAR	8	2	2	5	7					C7
90	CHAR	9	2	2	5	7					C8
100	CHAR	10	2	2	5	7					
110	CHAR	11	2	2	5	7					
120	CHAR	12	2	2	5	7					
130	CHAR	13	2	2	5	7					
140	CHAR	14	2	2	5	7					
150	CHAR	15	2	2	5	7					
160	CHAR	16	2	2	5	7					
170	CHAR	17	2	2	5	7					
180	CHAR	18	2	2	5	7					
190	CHAR	19	2	2	5	7					
200	CHAR	20	2	2	5	7					
210	CHAR	21	2	2	5	7					
220	CHAR	22	2	2	5	7					
230	CHAR	23	2	2	5	7					
240	CHAR	24	2	2	5	7					
250	CHAR	25	2	2	5	7					
260	CHAR	26	2	2	5	7					
270	CHAR	27	2	2	5	7					
280	CHAR	28	2	2	5	7					
290	CHAR	29	2	2	5	7					
300	CHAR	30	2	2	5	7					
310	CHAR	31	2	2	5	7					
320	CHAR	32	2	2	5	7					
330	CHAR	33	2	2	5	7					
340	CHAR	34	2	2	5	7					
350	CHAR	35	2	2	5	7					
360	CHAR	36	2	2	5	7					
370	CHAR	37	2	2	5	7					
380	CHAR	38	2	2	5	7					
390	CHAR	39	2	2	5	7					
400	CHAR	40	2	2	5	7					
410	CHAR	41	2	2	5	7					
420	CHAR	42	2	2	5	7					
430	CHAR	43	2	2	5	7					
440	CHAR	44	2	2	5	7					
450	CHAR	45	2	2	5	7					
460	CHAR	46	2	2	5	7					
470	CHAR	47	2	2	5	7					
480	CHAR	48	2	2	5	7					
490	CHAR	49	2	2	5	7					
500	CHAR	50	2	2	5	7					

SUBCASE 1

DISPLACEMENT VECTOR

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	-2.395461E-04
2	G	3.059795E-02	1.031030E-04	0.0	0.0	0.0	-1.583052E-04
3	G	4.360918E-02	2.062562E-04	0.0	0.0	0.0	1.285007E-05
4	G	0.0	0.0	0.0	0.0	0.0	-2.094123E-04
5	G	2.496502E-02	1.761390E-03	0.0	0.0	0.0	-1.429466E-04
6	G	4.118631E-02	1.760991E-03	0.0	0.0	0.0	3.613538E-04
7	G	1.729059E-02	2.164194E-10	0.0	0.0	0.0	-9.784228E-04
8	G	3.354708E-02	7.608822E-04	0.0	0.0	0.0	-1.466145E-05
9	G	0.0	0.0	0.0	0.0	0.0	-1.992926E-04
10	G	2.574427E-02	-1.760932E-03	0.0	0.0	0.0	-1.377539E-04
11	G	3.967312E-02	-1.750848E-03	0.0	0.0	0.0	-3.631710E-04
12	G	0.0	0.0	0.0	0.0	0.0	-2.192731E-04
13	G	2.815334E-02	-2.239402E-04	0.0	0.0	0.0	-1.479426E-04
14	G	4.261868E-02	-4.479604E-04	0.0	0.0	0.0	1.643559E-05

***USER INFORMATION MESSAGE--F88 TIME ESTIMATE TO FORM DATA BLOCK ULV N TYPE=NDP C 18 1 SEC, NUMBER OF PASSES = 1

*** USER INFORMATION MESSAGE 3035

FOR LOAD 1 EPSILON SUB E # -2.7152223E-15

*** USER INFORMATION MESSAGE 3035

FOR LOAD 2 EPSILON SUB E # -2.3636507E-15

*** USER INFORMATION MESSAGE 3035

FOR LOAD 3 EPSILON SUB E # -3.1959188E-16

SUBCASE 2

DISPLACEMENT VECTOR

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	-2.784249E-04
2	G	3.718306E-02	2.874010E-04	0.0	0.0	0.0	-2.177969E-04
3	G	6.272548E-02	5.748020E-06	0.0	0.0	0.0	2.573346E-05
4	G	0.0	0.0	0.0	0.0	0.0	-2.644139E-04
5	G	3.521879E-02	3.094987E-03	0.0	0.0	0.0	-2.048965E-04
6	G	5.901020E-02	3.092806E-03	0.0	0.0	0.0	-1.596072E-08
7	G	2.325157E-02	-3.441220E-23	0.0	0.0	0.0	-1.719437E-05
8	G	2.785845E-02	-1.632330E-17	0.0	0.0	0.0	-2.576539E-05
9	G	0.0	0.0	0.0	0.0	0.0	-2.644139E-04
10	G	3.521879E-02	-3.094987E-03	0.0	0.0	0.0	-2.048965E-04
11	G	5.901020E-02	-3.092806E-03	0.0	0.0	0.0	-1.596072E-08
12	G	0.0	0.0	0.0	0.0	0.0	-2.784249E-04
13	G	3.718306E-02	2.874010E-04	0.0	0.0	0.0	-2.177969E-04
14	G	6.272548E-02	-5.748020E-06	0.0	0.0	0.0	2.573346E-05

SUBCASE 3

DISPLACEMENT VECTOR

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	5.015203E-05
2	G	-4.818045E-03	-2.411911E-02	0.0	0.0	0.0	4.136970E-08
3	G	-1.191450E-05	-2.460211E-02	0.0	0.0	0.0	-5.922180E-03
4	G	0.0	0.0	0.0	0.0	0.0	5.016982E-05
5	G	-4.818045E-03	-2.091658E-02	0.0	0.0	0.0	3.533967E-08
6	G	-1.011783E-05	-2.699430E-02	0.0	0.0	0.0	1.449677E-03
7	G	-1.010371E-15	-3.625948E-02	0.0	0.0	0.0	9.742034E-15
8	G	-1.400335E-12	-3.701011E-02	0.0	0.0	0.0	-8.123062E-10
9	G	0.0	0.0	0.0	0.0	0.0	-5.016982E-05
10	G	4.818045E-03	-2.091658E-02	0.0	0.0	0.0	-3.533967E-08
11	G	1.011782E-05	-2.699430E-02	0.0	0.0	0.0	-1.449677E-03
12	G	0.0	0.0	0.0	0.0	0.0	-5.015203E-05
13	G	4.818045E-03	-2.411911E-02	0.0	0.0	0.0	-4.136970E-08
14	G	1.191449E-05	-2.460210E-02	0.0	0.0	0.0	5.922176E-03

SUBCOM 6

DISPLACEMENT VECTOR

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	-1.893940E-04
2	G	2.578137E-02	-2.411807E-02	0.0	0.0	0.0	-1.583238E-04
3	G	4.559726E-02	-2.960044E-02	0.0	0.0	0.0	-5.909324E-03
4	G	0.0	0.0	0.0	0.0	0.0	-1.592424E-04
5	G	2.210701E-02	-1.915519E-02	0.0	0.0	0.0	-1.429113E-04
6	G	4.118645E-02	-2.523330E-02	0.0	0.0	0.0	1.453291E-03
7	G	1.729058E-02	-3.625948E-02	0.0	0.0	0.0	-9.784227E-04
8	G	3.354707E-02	-3.624433E-02	0.0	0.0	0.0	-1.466225E-03
9	G	0.0	0.0	0.0	0.0	0.0	-2.496622E-04
10	G	3.054227E-02	-2.267751E-02	0.0	0.0	0.0	-1.377892E-04
11	G	3.968329E-02	-2.875314E-02	0.0	0.0	0.0	-1.453310E-03
12	G	0.0	0.0	0.0	0.0	0.0	-2.694249E-04
13	G	3.296945E-02	-2.412134E-02	0.0	0.0	0.0	-1.480239E-04
14	G	4.263060E-02	-2.960657E-02	0.0	0.0	0.0	5.938604E-03

SUBCOM 8

DISPLACEMENT VECTOR

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	-6.962100E-03
2	G	1.948240E-02	-2.411859E-02	0.0	0.0	0.0	-7.914122E-03
3	G	2.279267E-02	-2.960107E-02	0.0	0.0	0.0	-5.915750E-03
4	G	0.0	0.0	0.0	0.0	0.0	-5.453327E-03
5	G	8.664507E-03	-2.003589E-02	0.0	0.0	0.0	-7.143794E-03
6	G	2.057413E-02	-2.611380E-02	0.0	0.0	0.0	1.451464E-03
7	G	8.645292E-03	-3.625948E-02	0.0	0.0	0.0	-4.692113E-04
8	G	1.677353E-02	-3.662977E-02	0.0	0.0	0.0	-7.331537E-04
9	G	0.0	0.0	0.0	0.0	0.0	-1.498161E-04
10	G	1.768013E-02	-2.179705E-02	0.0	0.0	0.0	-6.891225E-03
11	G	1.984673E-02	-2.787372E-02	0.0	0.0	0.0	-1.451495E-03
12	G	0.0	0.0	0.0	0.0	0.0	-1.597885E-04
13	G	1.989326E-02	-2.412022E-02	0.0	0.0	0.0	-7.403264E-03
14	G	2.132180E-02	-2.960433E-02	0.0	0.0	0.0	5.930386E-03

SUBCOM 10

DISPLACEMENT VECTOR

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	-2.282727E-04
2	G	3.23648E-02	-2.41163E-02	0.0	0.0	0.0	-2.17755E-04
3	G	6.271350E-02	-2.95963E-02	0.0	0.0	0.0	-5.80642E-03
4	G	0.0	0.0	0.0	0.0	0.0	-2.162438E-04
5	G	3.040078E-02	-1.782159E-02	0.0	0.0	0.0	-2.048612E-04
6	G	5.90002E-02	-2.590149E-02	0.0	0.0	0.0	1.489661E-03
7	G	2.325157E-02	-3.625948E-02	0.0	0.0	0.0	-1.719435E-03
8	G	4.785845E-02	-3.701011E-02	0.0	0.0	0.0	-2.576617E-03
9	G	0.0	0.0	0.0	0.0	0.0	-3.195833E-04
10	G	4.003678E-02	-2.401157E-02	0.0	0.0	0.0	-2.049318E-04
11	G	5.902037E-02	-3.008710E-02	0.0	0.0	0.0	-1.489661E-03
12	G	0.0	0.0	0.0	0.0	0.0	-3.285767E-04
13	G	6.199963E-02	-2.412197E-02	0.0	0.0	0.0	-2.178382E-04
14	G	6.273720E-02	-2.960784E-02	0.0	0.0	0.0	5.947903E-03

SUBCOM 12

DISPLACEMENT VECTOR

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	0.0	0.0	0.0	0.0	0.0	-0.906043E-05
2	G	1.377495E-02	-2.411707E-02	0.0	0.0	0.0	-1.088571E-04
3	G	3.135082E-02	-2.959631E-02	0.0	0.0	0.0	-5.909304E-03
4	G	0.0	0.0	0.0	0.0	0.0	-6.203704E-03
5	G	1.279113E-02	-1.93608E-02	0.0	0.0	0.0	-1.024129E-04
6	G	2.969492E-02	-2.544749E-02	0.0	0.0	0.0	1.489661E-03
7	G	1.162578E-02	-3.625948E-02	0.0	0.0	0.0	-9.597182E-06
8	G	2.392922E-02	-3.701011E-02	0.0	0.0	0.0	-1.288350E-05
9	G	0.0	0.0	0.0	0.0	0.0	-1.823768E-04
10	G	2.242739E-02	-2.40407E-02	0.0	0.0	0.0	-1.024129E-04
11	G	2.951527E-02	-2.854070E-02	0.0	0.0	0.0	-1.489661E-03
12	G	0.0	0.0	0.0	0.0	0.0	-1.803645E-04
13	G	2.540810E-02	-2.41204E-02	0.0	0.0	0.0	-1.089398E-04
14	G	3.137465E-02	-2.960407E-02	0.0	0.0	0.0	5.945031E-03

SUBCASE 1

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	-1.242612E 00	-6.637262E-01	0.0	0.0	0.0	0.0
4	G	-1.117402E 04	-1.192228E 04	0.0	0.0	0.0	0.0
9	G	-1.117365E 04	1.192150E 04	0.0	0.0	0.0	0.0
12	G	-1.091223E 00	1.641072E 00	0.0	0.0	0.0	0.0

SUBCASE 2

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	-9.280188E-01	-1.650143E 00	0.0	0.0	0.0	0.0
4	G	-1.502407E 04	-1.726430E 04	0.0	0.0	0.0	0.0
9	G	-1.502407E 04	1.726430E 04	0.0	0.0	0.0	0.0
12	G	-9.280188E-01	1.650143E 00	0.0	0.0	0.0	0.0

SUBCASE 3

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	7.670296E-01	1.552667E 04	0.0	0.0	0.0	0.0
4	G	1.674154E 04	5.066129E 04	0.0	0.0	0.0	0.0
9	G	-1.674154E 04	5.066129E 04	0.0	0.0	0.0	0.0
12	G	-7.670296E-01	1.552667E 04	0.0	0.0	0.0	0.0

SUBCOM 6

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	-4.755614E-01	1.552600E 04	0.0	0.0	0.0	0.0
4	G	7.567523E 03	3.853901E 04	0.0	0.0	0.0	0.0
9	G	-2.991518E 04	6.238279E 04	0.0	0.0	0.0	0.0
12	G	-1.898251E 00	1.552811E 04	0.0	0.0	0.0	0.0

SUBCOM 8

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	1.457237E-01	1.552634E 04	0.0	0.0	0.0	0.0
4	G	1.315453E 04	4.450015E 04	0.0	0.0	0.0	0.0
9	G	-2.432836E 04	5.842204E 04	0.0	0.0	0.0	0.0
12	G	-1.312640E 00	1.552738E 04	0.0	0.0	0.0	0.0

SUBCOM 10

FORCES OF SINGLE-POINT CONSTRAINT

POINT ID.	TYPE	T1	T2	T3	R1	R2	R3
1	G	-1.809842E-01	1.552882E 04	0.0	0.0	0.0	0.0
4	G	3.717469E 03	3.319699E 04	0.0	0.0	0.0	0.0
9	G	-3.376540E 04	6.772556E 04	0.0	0.0	0.0	0.0
12	G	-1.895087E 00	1.552851E 04	0.0	0.0	0.0	0.0

FORCES OF SINGLE POINT CONTINUITY										SUBCOM 12	
POINT ID.	TYPE	Y1	Y2	Y3	R1	R2	R3				
1	G	3.030202E-01	1.532974E-04	0.0	0.0	0.0	0.0				
4	G	1.122950E-04	4.182914E-04	0.0	0.0	0.0	0.0				
9	G	-2.625352E-04	5.909343E-04	0.0	0.0	0.0	0.0				
12	G	-1.231030E-00	1.552759E-04	0.0	0.0	0.0	0.0				

FORCES IN BAR ELEMENTS (C B A R)										SUBCASE 1	
ELEMENT ID.	BEND-MOMENT END-A	PLANE 1	BEND-MOMENT END-B	PLANE 2	PLANE 1	PLANE 2	AXIAL FORCE	AXIAL TORQUE			
1	2.441408E-04	0.0	-1.194706E-02	0.0	6.637268E-01	0.0	-1.961242E-03	0.0			
2	-1.194707E-02	0.0	-1.168857E-02	0.0	-1.436136E-02	0.0	-3.366184E-03	0.0			
3	-1.168859E-02	0.0	2.595364E-02	0.0	-2.091236E-00	0.0	2.705664E-03	0.0			
4	2.595360E-02	0.0	0.0	0.0	1.441873E-00	0.0	1.101094E-03	0.0			
5	-6.443940E-08	0.0	-2.321428E-04	0.0	1.299324E-06	0.0	-3.917512E-03	0.0			
6	-1.100869E-04	0.0	1.625135E-02	0.0	-9.089708E-05	0.0	-1.043225E-04	0.0			
7	1.596069E-02	0.0	1.240313E-04	0.0	8.797649E-05	0.0	9.115887E-03	0.0			
8	1.100582E-04	0.0	-1.214004E-04	0.0	1.266104E-06	0.0	2.597816E-03	0.0			
9	0.0	0.0	1.789352E-02	0.0	-1.242603E-00	0.0	6.637250E-01	0.0			
10	1.789358E-02	0.0	3.662109E-04	0.0	1.242607E-00	0.0	6.637262E-01	0.0			
11	3.906250E-03	0.0	7.117444E-02	0.0	-4.942642E-00	0.0	2.987024E-03	0.0			
12	7.117383E-02	0.0	4.394531E-03	0.0	4.942598E-00	0.0	-6.777346E-01	0.0			
13	0.0	0.0	6.589792E-02	0.0	-4.576248E-00	0.0	-2.986246E-03	0.0			
14	3.589766E-02	0.0	3.417694E-03	0.0	4.576202E-00	0.0	3.533447E-00	0.0			
15	-2.441408E-04	0.0	1.571351E-02	0.0	-1.091218E-00	0.0	-1.441872E-00	0.0			
16	1.571357E-02	0.0	7.629395E-05	0.0	1.091220E-00	0.0	-1.441872E-00	0.0			

FORCES IN ROD ELEMENTS (C R O D)										SUBCASE 1	
ELEMENT ID.	AXIAL FORCE	TORQUE	ELEMENT ID.	AXIAL FORCE	TORQUE						
17	1.430338E-04	0.0	18	4.762652E-03	0.0						
19	-1.430338E-04	0.0	20	-4.785977E-03	0.0						

FORCES IN BAR ELEMENTS (C B A M)									
ELEMENT ID.	BEND-MOMENT END-A		BEND-MOMENT END-B		SHEAR		AXIAL FORCE		TORQUE
	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	
1	2.441406E-04	0.0	-3.330258E-02	0.0	1.850143E-00	0.0	-1.600914E-03	0.0	0.0
2	-3.330261E-02	0.0	0.0	0.0	-1.850143E-00	0.0	-4.925352E-03	0.0	0.0
3	-7.320219E-04	0.0	3.330259E-02	0.0	-1.850143E-00	0.0	4.925352E-03	0.0	0.0
4	3.330259E-02	0.0	2.441406E-04	0.0	1.850143E-00	0.0	1.600914E-03	0.0	0.0
5	-1.796259E-07	0.0	-4.078310E-04	0.0	2.264731E-06	0.0	-2.118141E-03	0.0	0.0
6	-1.930367E-04	0.0	3.215473E-04	0.0	-2.861023E-06	0.0	-1.290466E-04	0.0	0.0
7	-3.330934E-04	0.0	1.792908E-04	0.0	-2.861023E-06	0.0	2.118141E-03	0.0	0.0
8	1.930367E-04	0.0	-2.142149E-04	0.0	2.264731E-06	0.0	1.850142E-00	0.0	0.0
9	-9.785625E-08	0.0	1.336333E-02	0.0	-9.280157E-01	0.0	1.850143E-00	0.0	0.0
10	1.336348E-02	0.0	2.268618E-04	0.0	9.280176E-01	0.0	5.248576E-03	0.0	0.0
11	0.0	0.0	6.373455E-02	0.0	-4.426010E-00	0.0	-3.699219E-00	0.0	0.0
12	6.373359E-02	0.0	8.056641E-03	0.0	4.425888E-00	0.0	-5.248576E-03	0.0	0.0
13	0.0	0.0	6.373455E-02	0.0	-4.426010E-00	0.0	3.699219E-00	0.0	0.0
14	6.373359E-02	0.0	8.056641E-03	0.0	4.425888E-00	0.0	-1.850142E-00	0.0	0.0
15	-9.785625E-04	0.0	1.336333E-02	0.0	-9.280157E-01	0.0	1.850143E-00	0.0	0.0
16	1.336348E-02	0.0	2.268618E-04	0.0	9.280176E-01	0.0	-1.850143E-00	0.0	0.0

FORCES IN ROD ELEMENTS (C B D O)									
ELEMENT ID.	AXIAL FORCE		TORQUE		ELEMENT ID.	AXIAL FORCE		TORQUE	
	1	2	3	4		1	2	3	4
17	1.923451E-04	0.0	0.0	0.0	18	8.407750E-03	0.0	0.0	0.0
19	-1.923451E-04	0.0	0.0	0.0	20	-8.407750E-03	0.0	0.0	0.0

FORCES IN BAR ELEMENTS (CBAR)									
ELEMENT ID.	BEND-MOMENT END-A		BEND-MOMENT END-B		SHEAR		AXIAL FORCE		TORQUE
	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	
1	1.34997E 05	0.0	-3.96570E 04	0.0	9.70317E 02	0.0	7.67028E-01	0.0	0.0
2	-3.96573E 04	0.0	2.09080E 04	0.0	-3.16473E 02	0.0	4.99520E 00	0.0	0.0
3	2.09081E 04	0.0	-3.96573E 04	0.0	3.16478E 02	0.0	4.99520E 00	0.0	0.0
4	-3.96570E 04	0.0	1.34999E 05	0.0	-9.70316E 02	0.0	7.67028E-01	0.0	0.0
5	1.50744E-03	0.0	1.08523E-03	0.0	2.34559E-06	0.0	-1.53519E 00	0.0	0.0
6	1.30727E-03	0.0	1.07826E 03	0.0	-5.99013E 00	0.0	5.19541E 03	0.0	0.0
7	1.07826E 03	0.0	-9.76563E-04	0.0	5.99030E 00	0.0	-5.19541E 03	0.0	0.0
8	1.30727E-03	0.0	1.72993E-03	0.0	-2.34559E-06	0.0	-1.53519E 00	0.0	0.0
9	1.52549E-05	0.0	-1.10452E 02	0.0	7.67028E-01	0.0	-1.55266E 04	0.0	0.0
10	-1.10452E 02	0.0	9.15527E-05	0.0	-7.67030E-01	0.0	3.52988E 03	0.0	0.0
11	-2.44140E-04	0.0	-5.36857E 02	0.0	3.72617E 00	0.0	-1.03067E 04	0.0	0.0
12	-5.36859E 02	0.0	4.80281E-04	0.0	-3.72617E 00	0.0	1.03067E 04	0.0	0.0
13	2.44140E-04	0.0	5.36857E 02	0.0	3.72617E 00	0.0	-3.54710E 04	0.0	0.0
14	5.36859E 02	0.0	-4.80281E-04	0.0	-3.72617E 00	0.0	1.03067E 04	0.0	0.0
15	-1.52587E-05	0.0	1.10452E 02	0.0	-7.67028E-01	0.0	-1.55266E 04	0.0	0.0
16	1.10452E 02	0.0	-9.15527E-05	0.0	7.67030E-01	0.0	3.52988E 03	0.0	0.0

FORCES IN ROD ELEMENTS (CROD)									
ELEMENT ID.	AXIAL FORCE		TORQUE		ELEMENT ID.		AXIAL FORCE		TORQUE
	16	20	16	20			16	20	
17	-2.39960E 04	0.0			16		-6.66666E 03	0.0	0.0
19	-2.39960E 04	0.0			20		-6.66666E 03	0.0	0.0

SUBCOM 6

FORCES IN BAR ELEMENTS (C B A R)

ELEMENT ID.	BEND-MOMENT END-A		BEND-MOMENT END-B		SHEAR		AXIAL FORCE		TORQUE	
	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2
1	1.34996E 05	0.0	-3.97768E 04	0.0	9.70980E 02	0.0	-1.96047E 03	0.0	0.0	0.0
2	-3.97768E 04	0.0	2.07411E 04	0.0	-3.36480E 02	0.0	-3.36169E 03	0.0	0.0	0.0
3	2.07411E 04	0.0	-3.93977E 04	0.0	3.34383E 02	0.0	2.71016E 03	0.0	0.0	0.0
4	-3.93977E 04	0.0	1.34997E 05	0.0	-9.68673E 02	0.0	1.20185E 03	0.0	0.0	0.0
5	1.50738E 03	0.0	6.53094E 04	0.0	3.63491E 06	0.0	-3.91904E 03	0.0	0.0	0.0
6	1.97199E 03	0.0	1.07428E 03	0.0	-5.99045E 00	0.0	-5.21684E 03	0.0	0.0	0.0
7	1.07828E 03	0.0	-7.32421E 04	0.0	5.99045E 00	0.0	1.43113E 04	0.0	0.0	0.0
8	1.41734E 03	0.0	1.60769E 03	0.0	-1.05748E 06	0.0	2.59628E 03	0.0	0.0	0.0
9	0.0	0.0	6.84832E 01	0.0	-4.75578E 01	0.0	-1.55260E 04	0.0	0.0	0.0
10	6.84834E 01	0.0	1.22070E 04	0.0	4.75578E 01	0.0	-3.52902E 03	0.0	0.0	0.0
11	3.17382E 03	0.0	1.74885E 02	0.0	-1.21446E 00	0.0	-3.24840E 04	0.0	0.0	0.0
12	1.74879E 02	0.0	2.92688E 03	0.0	1.21441E 00	0.0	-1.03074E 04	0.0	0.0	0.0
13	-3.90625E 03	0.0	1.19580E 03	0.0	-8.30447E 00	0.0	-3.84572E 04	0.0	0.0	0.0
14	1.19583E 03	0.0	9.75625E 04	0.0	8.30436E 00	0.0	-1.03032E 04	0.0	0.0	0.0
15	-7.32421E 04	0.0	2.67588E 02	0.0	-1.85825E 00	0.0	-1.55261E 04	0.0	0.0	0.0
16	2.67587E 02	0.0	2.44140E 04	0.0	1.85824E 00	0.0	-3.53117E 03	0.0	0.0	0.0

SUBCOM 6

FORCES IN ROD ELEMENTS (C R O D)

ELEMENT ID.	AXIAL FORCE		TORQUE		ELEMENT ID.	AXIAL FORCE		TORQUE	
	18	20	18	20		18	20	18	20
17	-5.69270E 03	0.0	0.0	0.0	18	-1.08223E 03	0.0	0.0	0.0
19	-3.82966E 04	0.0	0.0	0.0	20	-1.14505E 04	0.0	0.0	0.0

FORCES IN BAR ELEMENTS (CBAM)									
SUBCOM 8									
ELEMENT ID.	BEND-MOMENT END-A		BEND-MOMENT END-B		SHEAR		AXIAL FORCE		TORQUE
	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	
1	1.34986E-03	0.0	-3.97171E-04	0.0	9.70489E-02	0.0	-9.79855E-02	0.0	0.0
2	-3.97189E-04	0.0	2.08496E-04	0.0	-3.38481E-02	0.0	-1.67859E-03	0.0	0.0
3	2.08496E-04	0.0	-3.95275E-04	0.0	3.35829E-02	0.0	1.35732E-03	0.0	0.0
4	-3.95271E-04	0.0	1.34998E-05	0.0	-9.69594E-02	0.0	6.51125E-02	0.0	0.0
5	1.50781E-03	0.0	9.69157E-04	0.0	2.99025E-04	0.0	-1.96028E-03	0.0	0.0
6	1.25243E-03	0.0	1.07827E-03	0.0	-5.99048E-04	0.0	-2.07167E-01	0.0	0.0
7	1.07827E-03	0.0	-9.76582E-04	0.0	5.99047E-04	0.0	9.75334E-03	0.0	0.0
8	1.36231E-03	0.0	1.66853E-03	0.0	-1.70154E-06	0.0	1.29737E-03	0.0	0.0
9	0.0	0.0	-2.09817E-01	0.0	1.45720E-01	0.0	-1.55263E-04	0.0	0.0
10	-2.09813E-01	0.0	3.05175E-04	0.0	-1.45723E-01	0.0	-3.52932E-03	0.0	0.0
11	-7.32421E-04	0.0	-1.60985E-02	0.0	1.25684E-01	0.0	-3.39775E-04	0.0	0.0
12	-1.60989E-02	0.0	1.26479E-03	0.0	-1.25687E-01	0.0	-1.03071E-04	0.0	0.0
13	1.22070E-03	0.0	8.66305E-02	0.0	6.01828E-01	0.0	-3.69841E-04	0.0	0.0
14	8.66304E-02	0.0	0.0	0.0	-6.01828E-01	0.0	-1.03050E-04	0.0	0.0
15	2.84180E-04	0.0	1.89020E-02	0.0	-1.31264E-01	0.0	-1.55273E-04	0.0	0.0
16	1.89020E-02	0.0	-3.05175E-05	0.0	1.31263E-01	0.0	-3.53039E-03	0.0	0.0

FORCES IN ROD ELEMENTS (CROD)									
SUBCOM 8									
ELEMENT ID.	AXIAL FORCE		TORSION		ELEMENT ID.		AXIAL FORCE		TORQUE
	10	20	10	20			10	20	
17	-1.68443E-04	0.0	0.0	0.0	18		-4.27350E-03	0.0	0.0
19	-3.11877E-04	0.0	0.0	0.0	20		-9.05780E-03	0.0	0.0

FORCES IN BAR ELEMENTS (C B A R)											SUBCOM 10	
ELEMENT ID.	BEND-MOMENT END-A		BEND-MOMENT END-B		SHEAR		AXIAL FORCE		TORQUE			
	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2		
1	1.34999E 05	0.0	-3.999038E 04	0.0	9.721670E 02	0.0	-1.640125E 03	0.0	0.0	0.0		
2	-1.999023E 04	0.0	2.099080E 04	0.0	-3.383240E 02	0.0	-4.928855E 03	0.0	0.0	0.0		
3	2.099011E 04	0.0	-3.932425E 04	0.0	3.386243E 02	0.0	4.928848E 03	0.0	0.0	0.0		
4	-3.932399E 04	0.0	1.349997E 05	0.0	-9.684651E 02	0.0	1.641637E 03	0.0	0.0	0.0		
5	1.507264E-03	0.0	6.77033E-04	0.0	4.611322E-06	0.0	-2.119680E 03	0.0	0.0	0.0		
6	1.113849E-03	0.0	1.078267E 03	0.0	-5.990368E 00	0.0	-7.709234E 03	0.0	0.0	0.0		
7	1.078264E 03	0.0	-6.765625E-04	0.0	5.990359E 00	0.0	1.810005E 04	0.0	0.0	0.0		
8	1.50723E-03	0.0	1.515279E-03	0.0	-8.086499E-08	0.0	2.116609E 03	0.0	0.0	0.0		
9	-1.708944E-03	0.0	2.314219E 01	0.0	-1.609993E-01	0.0	-1.552482E 04	0.0	0.0	0.0		
10	2.314208E 01	0.0	5.959248E-04	0.0	1.609964E-01	0.0	-3.527828E 03	0.0	0.0	0.0		
11	-7.612500E-03	0.0	1.004663E 02	0.0	-6.978760E-01	0.0	-3.022244E 04	0.0	0.0	0.0		
12	1.004727E 02	0.0	4.882813E-04	0.0	6.977234E-01	0.0	-1.031049E 04	0.0	0.0	0.0		
13	-7.612500E-03	0.0	1.174207E 03	0.0	-8.154266E 00	0.0	-4.071961E 04	0.0	0.0	0.0		
14	1.174158E 03	0.0	1.708984E-03	0.0	8.154068E 00	0.0	-1.030309E 04	0.0	0.0	0.0		
15	-1.953125E-03	0.0	2.440867E 02	0.0	-1.693060E 00	0.0	-1.552851E 04	0.0	0.0	0.0		
16	2.440844E 02	0.0	1.983643E-04	0.0	1.693064E 00	0.0	-3.531527E 03	0.0	0.0	0.0		

FORCES IN ROD ELEMENTS (C R O D)										SUBCOM 10	
ELEMENT ID.	AXIAL FORCE		TORQUE		ELEMENT ID.	AXIAL FORCE		TORQUE			
	17	18	19	20		03	04	03	04		
17	-8.761574E 03	0.0	0.0	0.0	18	1.742834E 03	0.0	0.0	0.0		
19	-8.323058E 04	0.0	0.0	0.0	20	-1.507261E 04	0.0	0.0	0.0		

FORCES IN BAR ELEMENTS (C B A R)											SUBCOM 12	
ELEMENT ID.	BEND-MOMENT END-A		BEND-MOMENT END-B		SHEAR		AXIAL FORCE		TORQUE			
	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2	PLANE 1	PLANE 2		
1	1.58986E 05	0.0	-3.98238E 04	0.0	9.712419E 02	0.0	-8.156914E 02	0.0	0.0	0.0		
2	-3.98237E 04	0.0	2.99030E 04	0.0	-3.37398E 02	0.0	-2.458180E 03	0.0	0.0	0.0		
3	2.99031E 04	0.0	-3.94907E 04	0.0	3.35593E 02	0.0	2.467172E 03	0.0	0.0	0.0		
4	-1.94905E 04	0.0	1.34999E 05	0.0	-9.693901E 02	0.0	8.212266E 02	0.0	0.0	0.0		
5	1.507354E-03	0.0	8.513229E-04	0.0	3.477952E-06	0.0	-1.060605E 03	0.0	0.0	0.0		
6	1.210348E-03	0.0	1.078267E 03	0.0	-5.990365E 00	0.0	-1.256914E 03	0.0	0.0	0.0		
7	1.078267E 03	0.0	-7.324219E-04	0.0	5.990361E 00	0.0	1.164773E 04	0.0	0.0	0.0		
8	1.404005E-03	0.0	1.622367E-03	0.0	-1.213237E-06	0.0	1.057339E 03	0.0	0.0	0.0		
9	-2.441006E-04	0.0	-4.363309E 01	0.0	3.030128E-01	0.0	-1.552574E 04	0.0	0.0	0.0		
10	-4.363307E 01	0.0	3.204346E-04	0.0	-3.030214E-01	0.0	-3.528754E 03	0.0	0.0	0.0		
11	-1.953125E-03	0.0	-2.181800E 02	0.0	1.515167E 00	0.0	-3.284673E 04	0.0	0.0	0.0		
12	-2.181804E 02	0.0	2.441406E-03	0.0	-1.515228E 00	0.0	-1.030864E 04	0.0	0.0	0.0		
13	-2.441406E-04	0.0	8.555271E 02	0.0	-5.941162E 00	0.0	-3.809532E 04	0.0	0.0	0.0		
14	8.555198E 02	0.0	-9.76525E-04	0.0	5.941116E 00	0.0	-1.030844E 04	0.0	0.0	0.0		
15	0.0	0.0	1.772700E 02	0.0	-1.231042E 00	0.0	-1.552759E 04	0.0	0.0	0.0		
16	1.772695E 02	0.0	4.577637E-05	0.0	1.231038E 00	0.0	-3.530402E 03	0.0	0.0	0.0		

FORCES IN ROD ELEMENTS (C R O D)										SUBCOM 12	
ELEMENT ID.	AXIAL FORCE		TORQUE		ELEMENT ID.	AXIAL FORCE		TORQUE			
	17	18	19	20		17	18	19	20		
17	-1.437883E 04	0.0	0.0	0.0	17	-2.461019E 03	0.0	0.0	0.0		
19	-3.361333E 04	0.0	0.0	0.0	20	-1.066877E 04	0.0	0.0	0.0		

OUTLOOK FOR THE USE OF COMPUTERS IN THE
MILITARY CONSTRUCTION DESIGN PROCESS

by
Donald B. Baldwin*

The Present and Recent Past

In recent years, the scope of architectural and engineering design has been expanded to include more detailed examination of factors. Stated another way, the design process has been complicated by a variety of new constraints and requirements, both technical and statutory. The facility design process has been made more complex by many factors. Some of them are environmental considerations, both health and economics motivated. Rapid rates of inflation and the direct effect on material and construction costs, energy conservation considerations, and the effects of energy shortages on facility operation and maintenance costs have also added to design complexity. Being required to take all of these factors into account when planning and designing a military facility has made it difficult for the Corps' professional designers to do their job. Design accountability is much harder to maintain. Without some form of rapid, computer-aided design tool, the capacity of engineers and architects to objectively examine and evaluate a variety of alternates to determine the best compatible set to use in a particular facility design is severely restrained. It is important for designers to respond rapidly, and in a rational and objective manner, to budget cuts and other factors, which can have a strong impact on a chosen set of design alternates at any time during the design process. Designers frequently lack a clearly defined audit trail of the design decisions, which have been made up to any given time, and their effect on cost, as well as the effect of cost on design decisions. This lack is a serious

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drawback in the Corps' design environment.

Until recently, the Corps, like many other organizations in the design and construction business, has used the computer to aid the engineer in the execution of relatively single purpose design functions. For example, structural engineers are using programs such as ICES-STRU DL, SAP, and EASE to analyze or design structural frames for large facilities. In a similar manner, mechanical engineers are using TRACE, ECUBE, and ACCESS to aid in the design and analysis of HVAC systems for some of these same structures. However, only a very few engineers are trying to interconnect and interface the functions of these various different programs and engineering disciplines in such a coordinated way as to be able to perform integrated, cross-discipline analysis and design. Although there are time and money to be saved through the effective use of these various single-purpose, single-discipline programs, a much greater benefit can be realized through their organized and coordinated use. The tendency in the past has been to focus our attention on the examination of each individual tree rather than step back and try to take an overall view of the collection of trees as a forest. A building facility is not so unlike this forest, with each of its subsystems, i.e., structural, mechanical, electrical, etc., representing a different tree.

The Outlook in Computer-Aided Design

A look at our past and present use of the computer in engineering design, together with the multitude of complex factors that today's designer must take into account, clearly indicates that a more effective use of the computer is required. The technology advancements in computer hardware are far ahead of the engineering applications programs and systems that the Corps currently uses. The realization of this need has prompted the Military Construction Directorate to embark on the development of a computer system whose primary function will be the coordinated integration of all of the various engineering and architectural functions and disciplines that normally make up the MCA design process. The Automated Engineering and Architectural Design System,

AEADS, is being designed and developed specifically to support the military construction design responsibility of the Corps. AEADS will not be an "automatic" design system, as its name implies to some. Rather, it will be a "computer-aided" design system that employs an optimum mix of state-of-the-art software and state-of-the-technology hardware to aid the professional in the design decision-making process. We are not attempting to automate the process in the sense of "push-button" design; we do not believe that either the design process itself or the state-of-the-art and technology in computer science are well enough understood and advanced to produce such an automatic system. The AEADS will provide an on-line, man-machine interface which will directly involve the professional in all of the decision making that takes place in the facility design process. The professional will be able to focus more of his attention on the vital decision-making aspects of design and become less bogged down in the technical level details which consume so much of his time at present.

Objectives of the AEADS

The basic objectives of the AEADS are to:

- a. Improve the quality of design.
- b. Improve design responsiveness.

Improving the quality of the MCA design product can be accomplished by consideration of:

- a. Development of structured relationships between decisions made during the design process and the impact of these decisions on the quality of the final product.
- b. Improvement of the process whereby facility design is continually reviewed during the design process to ascertain compliance with criteria including functional adequacy, budgetary restrictions, and user needs.
- c. Ability to derive facility criteria from user requirements and to include innovative design and construction techniques.
- d. Capability to examine and minimize life cycle costs within the limits of the desired functional criteria.

- e. Development of facility design which minimizes the impact of the facility on the total environment.

On the other hand, improving the responsiveness of design can be accomplished by consideration of such things as:

- a. Maximizing the number of design alternates examined while minimizing the impact on the time span of the total design process, i.e., consider more design alternates in a much shorter time span.
- b. Increasing the level of capacity and readiness of the Corps' professional design staff in architectural and engineering design activities, i.e., increase and improve the productivity of the Corps' professional design staff.
- c. Providing an organized format for the standardization of computer software and hardware to support a more systematic and accountable design process.

AEADS Development Strategy

The development of such a large and integrated software/hardware system is very complex and must be approached in phases. Although the AEADS will address the entire spectrum of facility design, first priority will be given to developing the system at the opposite ends of the spectrum, i.e., the concept development phase and the final review phase of the design process. These two areas are where the bulk of the in-house effort is currently concentrated. Second priority will be given to the development of the remainder of the design process, including technical design computations and the actual production of final contract documents. In any case, the high payoff areas that are identifiable in the MCA cycle will be implemented as quickly as possible.

While the overriding goal of the AEADS development will be the eventual integration of all of its component parts and subsystems, nevertheless, whenever possible, the product(s) of any one phase will be designed to be operable on a stand-alone basis. In this way, parts of the system may be field tested and used for productive work before the final system integration is accomplished. The best available technical design software packages will be used by the system as much as

possible. New technical design software packages will be developed for the AEADS only if such software does not already exist from some other source.

The AEADS development is being treated by MC/OCE as a full-scale project. The U. S. Army Construction Engineering Research Laboratory at Champaign, Illinois, has been given the responsibility for planning and developing the system. The CERL AEADS Project Manager, Mr. David Sides, is formulating an AEADS Project Development Plan and Schedule. Over the next 5 yr, from 10 to 20 million dollars will be spent on the AEADS development. The Project Manager will be using the best available people from both the private and Government sectors of the profession to design and build the AEADS. AEADS development will be carried out with close consultation and cooperation with Corps district and division professional personnel. A project Monitor Team at OCE is monitoring and giving general technical direction to the AEADS Project Manager in the system's development. This Monitor Team will also serve as the focal point of AEADS coordination between Civil Works and Military Construction Directorates as well as other DOD and Government agencies.

The phased development strategy of the AEADS is perhaps best illustrated by two of its current products, SEARCH and the DD 1391 Checker.

SEARCH

(Systematic Evaluation and Review of Criteria for Habitability)

Briefly stated, SEARCH is a set of computer programs that are used in conjunction with two special graphic input devices by architects to evaluate concept plans that are submitted to the Army for approval. The system accepts information from Space Utilization Guides and other criteria documents together with a graphic description of building floor plans; it then evaluates the plans submitted by these specified criteria. SEARCH functions as a geometrical space relationship checker. It not only performs these criteria checks but also informs the user when and where criteria conflicts occur and gives an indication of their severity. The user is in control of the system at all times, and it produces

an audit trail of the source of all criteria; it uses this during the analysis.

DD 1391 Checker

Although the 1391 Checker is only partially operational, it is already proving to be a very useful, time-saving tool in the checking of the cost estimate portion of DD 1391's. When completed, the Checker will provide a computer-aided procedure for assisting master planners and all others normally involved in verifying that applicable DOD, DA, and CE requirements and regulations have been considered when a project is submitted for authorization. In its present form, the Checker is used in an on-line interactive mode by estimators to price out a project with the assurance that the cost computed is within statute and criteria of DOD, AR, and ER guidance. The cost checker portion of the DD 1391 Checker can generate as well as check the cost data for any DD 1391.

Other Features of AEADS Currently Under Development

One of the functions of AEADS will be its ability to produce project specifications based on the automatically recorded design decisions made by architects and engineers during the design process. Part of this process involves the tailoring of standard guide specifications to particular projects. Initially, this tailoring will be accomplished by an on-line text editor, EDITSPEC, which is currently under development.

In the area of cost estimating, AEADS will be designed to provide cost breakdowns at various levels of detail and at different times during the facility design process. The costs will be keyed to specific design decisions through an intricate data structuring scheme. At concept stage, costs given would be based in large part on historical and empirical data; at later times in design development, these costs will be based on actual material takeoffs. Life cycle as well as first cost values will be given by the system.

AEADS Coordination and Integration

Although the early-on, stand-alone products such as SEARCH and the DD 1391 Checker serve a useful and productive purpose in their own right, the greater benefit is to be achieved by providing the overall framework of the AEADS for their systematic and integrated use. The system must provide design accountability via a design decision audit trail as well as the ability to directly interface the various design disciplines and functions. For example, when a mechanical engineer makes the design decision to use a particular type of HVAC system or to consider several such alternate systems, all other functions and parts of the design process must be checked by the AEADS to: (a) make sure that criteria are not violated, (b) determine the impact, if any, on the other decisions that have already been made by other engineers, (c) determine the required sections of guide specifications that are needed, and (d) determine the initial and, in some cases, the life cycle cost of the alternate(s) to be considered. In addition, some design decisions must be analyzed in regard to their possible impact on environmental and energy conservation aspects. The ability to make, review, and evaluate such design decisions at any stage of the facility design process in a dynamic way can be a very powerful and effective use of the computer as a tool in design. Eventually the AEADS will be linked with other software systems being developed that will monitor the construction and operation phases of facilities. This linkup will provide a vital direct feedback mechanism which the AEADS can use to modify the design criteria that will be used in future projects.

Summary

The AEADS Project is a very ambitious undertaking, and OCE is fully committed to its development and implementation. The best qualified experts in engineering software design and data handling both in and out of Government will be used in building the system. Successful design and implementation of the AEADS will depend in large part on the

joint cooperation and the concerted effort of Corps professional personnel at all levels. It will be field tested in districts, divisions, and OCE at every step of the way. The system's software and hardware will be designed with the end user, the practicing engineer and architect, in mind. The expenditure in time and resources will be considerable; we believe the commitment will be well worth the effort. Within the next few months, a joint CW/MC letter will be sent to all district and division offices giving information on AEADS and requesting their input and support as users in the system's planning and development. Due to its size, the AEADS Project development is being coordinated with other DOD and Federal agencies.

Appendix A: Memorandum For Record

6 October 1975

MEMORANDUM FOR RECORD

SUBJECT: Report on the Corps-Wide Conference on Computer-Aided Design in Structural Engineering, September 22-26, 1975, New Orleans, LA

1. Although the conference was started in style by the near miss of hurricane Eloise, there were over 180 participants, with EURDIV and MEDDIV being the only divisions not represented. A total of eight people from OCE participated in the conference, seven from the Civil Works Directorate, and one from Military Construction.

2. The general session papers presented by the CW Directorate representative and the representatives of the various division offices were excellent and very enlightening. It was encouraging to know that so many of the divisions and districts are now pursuing effective use of the computer in structural design and analysis as well as in other areas of the engineering profession. The specialty sessions proved to be very productive. The session I chaired (Matrix Analysis Methods, Frames, and Military Construction) was given twice to a total of 81 persons. A list of the session attendees is inclosed. In addition, the SEARCH demonstration was given a total of fifteen times by Dale Bryant and Bruce Dains of CERL, so that every conference participant received close exposure to the system.

3. During the general and specialty sessions, a number of serious issues and important problems were surfaced and discussed--some in great detail. The following are a few of the more important items that were raised.

a. The Corps is rapidly losing its in-house capability to do engineering design and review work. The Corps is rapidly becoming the "Corps of Clerks" instead of the Corps of Engineers. In addition, not enough challenging design work is being done in-house to adequately train and attract or hold on to young engineers. In the MC area, work loads are scheduled without apparent regard for the in-house capability to perform the work. More often than not, the short time span allowed for MC work does not allow engineers to become familiar with the potential benefits of computer-aided design. It was suggested by some division speakers that if the Corps is going to continue with its current work load level and manpower level, then OCE should seriously consider farming out to A&E consultants the preparation of project specifications and estimates, and performing more actual design work in-house. The consensus of the division speakers, as well as the participants, was that unless engineers are kept actively involved in actual design work, they will soon be virtually useless as design reviewers.

b. Many of those present who are involved in MC work expressed a real need to find ways to involve the computer more in all of the various phases of the MCA design process, not just in the technical design

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calculation stage. In particular, the computer needs to be applied more at the concept and review stages of the design process. We need to be using the computer to do better design very early in the concept phase.

c. The reluctance of supervisors to allow their people to use the computer in design is due in part to lack of confidence in the computer on the part of the supervisors. It was suggested that a training program be instituted by the Corps to educate supervisors in the capabilities and benefits of computer-aided design.

d. The general consensus of all conference participants was that the conference should be repeated on a periodic basis. One division representative suggested that consideration be given to dividing future conferences into two parts. One part would be specifically aimed at the supervisors and the other part devoted to the designers. In this way, the short time constraints revealed in this conference would be corrected. The consensus was that there was not enough time in any of the sessions to discuss the problems surfaced in adequate detail.

e. It was suggested that either an OCE or division-wide panel of professional engineers be established to determine the long-range computer hardware and software needs of the Corps. In particular, it was suggested that this high level, professional panel should be recommending new software development, procurement, and use throughout the Corps based on projected Corps workloads.

f. It was recommended that greater use be made of currently available computer programs from private industry.

g. It was requested that OCE provide funds and take a strong position with regard to the proper and adequate documentation of in-house developed computer programs. Too many of these existing programs are virtually useless to people other than the originator without good user documentation. In nearly every case, the author of an in-house program is either too busy to properly document his work or else his supervisors discourage him from taking the time to do this very vital task. OCE needs to recognize this need and take positive steps to correct the problem.

h. Nearly all conference participants expressed a need to use computer graphics more for pre- and post-processing of program data and results. One of the major drawbacks to using the larger design and analysis programs is the inordinate amount of time it takes the professional to express his problem to the computer and the often very complicated and time-consuming problem of correctly reading and interpreting the results. Computer graphics appears to have great potential

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in both areas. The use of conversational, easy to use, and understand man-machine interface software is another area that should be pursued more strongly.

1. While there were many other very important issues that were made and discussed by the participants, these are some of the most important and were, by far, the points on which nearly every participant agreed.

4. Although the material presented at the specialty sessions was predominantly civil works oriented, the division papers and specialty session discussions indicated about a 60 percent to 40 percent (CW vs. MC) division in participant interest. In addition, there was a general expression on the part of nearly all of the participants for the desire to have OCE state clearly and definitively its policy and support regarding the use of computers in the engineering design process.

5. Sometime within the next two months, representatives of WES will make a formal presentation to the Civil Works and Military Construction Directorates on the results and outcome of the conference. All invited OCE, division, and specialty session speakers are due to submit the final drafts of their presentations as written papers, to be included in the conference proceedings, to WES by 24 October 1975. The proceedings will be published during the first calendar quarter of 1976.

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DON BALDWIN
AEADS Project Monitor

APPENDIX A: BIOGRAPHICAL SKETCHES OF AUTHORS

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ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MISS F/G 9/2
CORPS-WIDE CONFERENCE ON COMPUTER-AIDED DESIGN IN STRUCTURAL EN--ETC(U)
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Mr. William D. Ashton is a Structural Design Engineer working with the Rock Island District, Corps of Engineers, Illinois. He has his BS and MS degrees in Civil Engineering from the University of Iowa. His experience in the design area include the structural inspection and evaluation of numerous navigation structures and highway and railroad bridges, design of several highway and railroad bridges, and other typical Corps of Engineers application areas. He has been very active in developing computer programs for design-analysis and has taught several short courses on the "Stiffness Method of Structural Analysis." He is the author of numerous publications and is the joint author (with Dr. B. L. Meyers) of a book (to be published) on "Stiffness Method of Structural Analysis."

Mr. Donald B. Baldwin graduated in 1957 from the University of Louisville, in Kentucky, with a Bachelor of Civil Engineering degree. He received an M.S. in Engineering from George Washington University in 1969, and, in 1972, a Master of Civil Engineering degree from the University of Louisville. He has worked as a Civil Engineer, General Engineer, and as a Specialist in Structural Dynamics. Currently, he is employed as a General Engineer, Advanced Technology Branch, OCE, and is primarily responsible for the planning and design of AEADS. In Kentucky he is registered as a Professional Civil Engineer; he is also a Certified Fallout Shelter Analyst. Mr. Baldwin is a member of ASCE's Technical Council on Computer Practices, the Federal Construction Council of the National Academy of Sciences, the Standing Committee on Computer Technology for the Building Research Advisory Board, and the Reinforced Concrete Research Council. His publications include: "Professional Recognition Through Registration," Civil Engineering Magazine; a technical report, Soil Thermal Conductivity Investigation for Underground Shelters; and co-authorship on Design and Evaluation of a 480-Person Austere Community Fallout Shelter.

Daniel W. Reynolds received a B.S. degree in Civil Engineering from the University of Wyoming at Laramie in 1959, and holds an Engineering-in-Training Certificate issued by Wyoming. He has served with the Corps as a Civil Engineer, Missouri River Division; and Construction Engineer

Ballistic Missile Construction Office, in Denver, Colorado, and Roswell, New Mexico. While working as a Structural Engineer, Military Design Branch, Alaska District, he helped with reconstruction after the Prince William Sound, Alaska, earthquake of 1964. In the 10 yr since joining the Military Design Branch, Sacramento District, he has worked in General and Civil Engineering, and is now serving as a Structural Engineer.

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Corps-Wide Conference on Computer-Aided Design in Structural Engineering, New Orleans, La., 1975.

[Proceedings ... held in New Orleans, Louisiana, 22-26 September 1975, Vicksburg, Miss., Automatic Data Processing Center, U. S. Army Engineer Waterways Experiment Station, 1976-

12 v. illus. 27 cm.

Contents.-v.1. Management report.-v.2. List of computer programs for CADSE.-v.3. Invited speeches and technical presentations.-v.4. Division presentations.-v.5. State-of-the-Corps-Art (SOCA) reports on gravity monoliths, U-frame locks, and channels.-v.6. SOCA reports on gates, stoplogs, and trashracks.-v.7. SOCA reports on single- and multiple-cell conduits and tunnels.-v.8. SOCA reports on pile foundations and sheet pile cells.-v.9. SOCA reports on sheet pile walls and T-walls.-v.10. SOCA reports on stiffness methods, frames, and military construction.-v.11. SOCA reports on earthquake and dynamic analyses.-v.12. Interactive graphics, SEARCH and CORPS systems.

(Continued on next card)

Corps-Wide Conference on Computer-Aided Design in Structural Engineering, New Orleans, La., 1975.

[Proceedings ...] 1976-
(Card 2)

1. Computer-aided design -- Congresses. 2. Design -- Congresses. 3. Structural engineering -- Congresses.
I. U. S. Army. Corps of Engineers. II. U. S. Waterways Experiment Station, Vicksburg, Miss.
TA641.C67 1975